University of Alberta

The Role and Effectiveness of Drinking Water Quality Guidelines for Managing Public Health Risks

by

Leanne Michelle Varkonyi ©

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Abstract

Risk assessment plays a key role in environmental guideline development throughout the world. Health Canada works with provincial and territorial representatives to establish the *Guidelines for Canadian Drinking Water Quality* (GCDWQ), based on risk management concepts. This thesis evaluates the role and effectiveness of the GCDWQ for managing public health risks through a critical review of recent guideline development initiatives and the field application of select guideline values. Semi-structured interviews with 28 public health professionals were conducted to collect information on their level of knowledge and understanding about guideline derivation and application and to determine the degree to which guidelines are being applied in a manner likely to reduce overall public health risk. The findings suggest that a clearer scientific framework and set of priorities should be established for guideline development and application in Canada to promote preventive public health risk management.

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List of Abbreviations

ACPHHS	Advisory Committee on Population Health and Health Security
AEPEA	Alberta Environmental Protection and Enhancement Act
AO	aesthetic objective
BDCM	bromodichloromethane
Cal EPA	California Environmental Protection Agency
CCOHS	Canadian Center for Occupational Health and Safety
CCME	Canadian Council of Ministers of the Environment
CDW	Federal-Provincial-Territorial Committee on Drinking Water
CHE	Federal-Provincial-Territorial Committee on Health and the Environment
CWN	Canadian Water Network
DBCM	chlorodibromomethane
DBPs	disinfection byproducts
E. coli	*Escherichia coli*
EC	European Commission
EU	European Union
GCDWQ	*Guidelines for Canadian Drinking Water Quality*
ILCR	incremental lifetime cancer risk
LMS	linearized multi-stage model
LOAEL	lowest observed adverse effects level
MAC	maximum acceptable concentration

List of Abbreviations (Cont'd)

MCL	maximum contaminant level
µg/L	micrograms per litre
mg/L	milligrams per litre
MHO	medical health officer
NHMRC	National Health and Medical Research Council
NZMOH	New Zealand Ministry of Health
NOAEL	no observed adverse effects level
NTP	National Toxicology Program
OEHHA	Office of Environmental Health Hazard Assessment
OG	operational guidance value
%	percent
PHAC	Public Health Agency of Canada
PHG	preliminary health goal
PQL	practical quantitation limit
QA/QC	quality assurance/quality control
RHA	regional health authority
TDI	tolerable daily intake
THMs	trihalomethanes
UF	uncertainty factor
U.S. EPA	United States Environmental Protection Agency

List of Abbreviations (Cont'd)

WHO	World Health Organization
WQHB	Water Quality and Health Bureau

1. Introduction

1.1. Background

When the safety of our drinking water is compromised, it poses an enormous public health risk. Fortunately, once common disease outbreaks from drinking water have become relatively rare. Yet, given our current level of knowledge and technology they remain more common than they should be (Hrudey and Hrudey, 2004). In Canada, federal, provincial and municipal governments have implemented several programs to help manage this risk. One of these programs is the development of federal drinking water guidelines, primarily in the form of maximum acceptable concentrations (MACs) for individual contaminants. Health Canada's Water Quality and Health Bureau (WQHB) works with provincial and territorial representatives to establish the *Guidelines for Canadian Drinking Water Quality* (GCDWQ), based on risk management concepts. Guidelines are recommended benchmarks against which water quality can be assessed, but are not legally enforceable. These numerical guideline values are considered to be one element in a multi-barrier approach to ensuring the safety of drinking water in Canada (CCME, 2004).

In some aspects, the development and implementation of conventional numerical drinking water quality guidelines has made risk management decisions easier for public health professionals by allowing the comparison of drinking water quality monitoring results to numerical guideline values. The result of this comparison, at least in theory (*i.e.*, whether there is an exceedance of a guideline value or not), can assist in the determination of whether the presence of a substance in drinking water at the reported concentration constitutes a public health risk. To that end, the application of the GCDWQ plays a role in managing public health risks from drinking water in Canada.

The Health Canada website states: "[Health Canada's WQHB's] mandate and expertise lies in protecting the health of all Canadians by developing the *Guidelines for Canadian Drinking Water Quality*" and "The *Guidelines for Canadian Drinking Water Quality* are designed to provide Canadians with access to wholesome and safe drinking water" (Health Canada, 2008). Although it is reasonable to expect that providing safe and reliable drinking water reduces risks to public health, it may not be reasonable to assume that the GCDWQ alone provide Canadians with access to safe drinking water let alone protect the health of all Canadians. Further, the interpretation and application of the GCDWQ is left to provincial and municipal governments and to a large extent, individual public health professionals. Failure to establish a clear framework and set of priorities for guideline value development and application may result in reactive and inconsistent risk management decision making. For these reasons, the role and effectiveness of the GCDWQ as a measure for managing public health risks is open to evaluation.

1.2. Research Design

1.2.1 Research Hypothesis

A more clearly defined scientific framework and set of priorities is required for the development and effective application of drinking water quality guidelines to support preventive public health risk management decision making in Canada.

1.2.2 Research Question

Do drinking water quality guidelines, as currently presented, provide an effective means for managing public health risks?

1.2.3 Ethics Approval

The proposed research study, including the information letter, consent form and interview guide were reviewed and approved by the Faculty of Medicine and Dentistry Health Research Ethics Board of the University of Alberta in December 2006.

1.3. Research Objectives

The objective of the study is to evaluate the role and effectiveness of drinking water quality guidelines for managing public health risks in Canada. Specific study objectives are listed below.

1. Identify how public health professionals with responsibility for assuring the safety of drinking water interpret and apply the GCDWQ in their jurisdictions.
2. Evaluate the knowledge and understanding that public health professionals have,

regarding the guideline development process, the level of uncertainty involved and the resulting implications for the application of the numerical guideline values.

3. Determine how public health professionals reasonably interpret various risk management principles and concepts that have important implications for assuring safe drinking water.
4. Evaluate the perceptions and beliefs of public health professionals on the role of the GCDWQ when it comes to assuring safe drinking water and overall public health risk management decision making.
5. Obtain insight into the expectations that public health professionals have of varying levels of government and stakeholders and solicit recommendations regarding how best to develop and apply drinking water quality guidelines to provide the greatest benefit to public health.

It is anticipated that this information will be used to form the basis for additional guidance and recommendations that will allow public health professionals to make better informed and appropriate risk management decisions that aim to reduce overall population health risk.

2. Review of Relevant Literature and Research

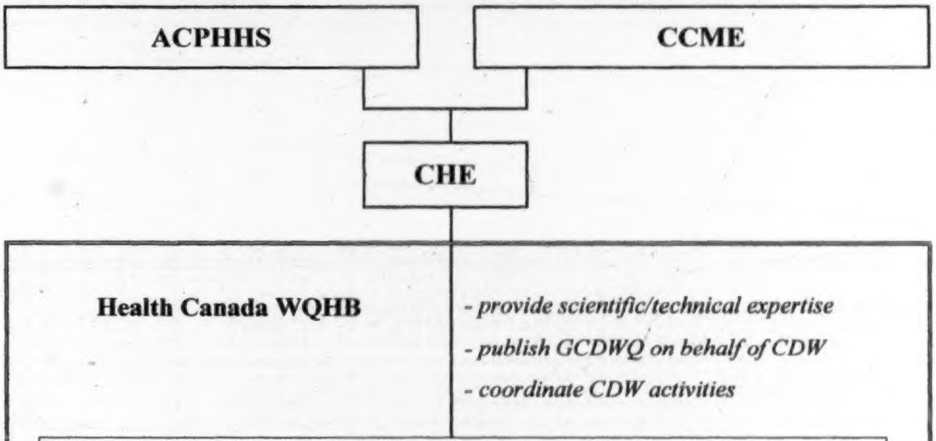
A review of applicable literature, articles and legislation pertaining to drinking water safety was conducted to: 1) summarize the guideline development and implementation process in Canada; 2) highlight broad issues with risk assessment and risk management and the resulting inherent limitations of numerical guideline values; 3) provide an overview of recent drinking water risk management research and concepts; and 4) provide a critical appraisal of recent guideline development initiatives and the field application of select guideline values. This review is summarized below.

2.1. Guideline Development and Implementation

In Canada, ensuring the safety of drinking water is a responsibility that is shared between provincial, territorial, federal and municipal governments. The federal government is responsible for establishing the GCDWQ. Health Canada's WQHB, together with provincial and territorial representatives on the Federal-Provincial-Territorial Committee on Drinking Water (CDW) establish the GCDWQ which are "designed to provide Canadians with access to wholesome and safe drinking water" (Health Canada, 2008). Guidelines for drinking water quality have been established for a variety of microbiological, chemical, physical and radiological parameters. Information pertaining to the guideline development process can be found on the Health Canada Website and is detailed in two published documents: *Approach to the Derivation of Drinking Water Guidelines* and *Canadian Drinking Water Guidelines Development Process* (Health Canada, 1995 and 1999).

The CDW is a national committee that reports to the Federal-Provincial-Territorial Committee on Health and the Environment (CHE). The CHE reports to the Advisory Committee on Population Health and Health Security (ACPHHS) and the Canadian Council of Ministers of the Environment (CCME) on health and environmental issues, respectively. The CDW has also worked in collaboration with the CCME on the development of the multi-barrier approach to safe drinking water (CCME, 2004). For the development of the GCDWQ, Health Canada's WQHB provides scientific and technical expertise to the CDW, publishes the GCDWQ and coordinates overall CDW activities (Health Canada, 1999). The general reporting relationship is summarized in Figure 1.

Figure 1. Parties Involved in the Development and Approval of the Guidelines for Canadian Drinking Water Quality.



- provide scientific/technical expertise
- publish GCDWQ on behalf of CDW
- coordinate CDW activities

CDW

14 Voting Members	Alberta	Alberta Environment
	British Columbia	Ministry of Health Services
	Manitoba	Department of Water Stewardship
	New Brunswick	Department of Health and Wellness
	Newfoundland and Labrador	Department of Environment and Conservation
	Northwest Territories	Stanton Territorial Health Authority
	Nova Scotia	Department of Environment and Labour
	Nunavut Territory	Department of Health and Social Services
	Ontario	Ministry of the Environment
	Prince Edward Island	Department of Environment, Energy and Forestry
	Québec	Ministère du Développement durable, de l'Environnement et des Parcs
	Saskatchewan	Department of the Environment
	Yukon Territory	Department of Health and Social Services
	Federal	Health Canada
3 Non-voting Members	CHE Representative	
	CCME Representative	
	Canadian Advisory Council on Plumbing Representative	

2.1.1 Guideline Development Process

It is recognized that the guideline development process can be challenging and somewhat of a balancing act. The process must remain flexible enough to accommodate the diverse needs of various jurisdictions (Health Canada, 1999). Therefore, effort must be made to avoid being overly prescriptive or too conservative but at the same time ensure the protection of public health. Guidelines are typically only developed for parameters that are of concern at the national or regional level rather than those identified on a limited or local scale. Six phases of guideline development have been identified: 1) identification; 2) assessment; 3) evaluation; 4) decision making and approval; 5) announcement and publication; and 6) re-evaluation (Health Canada, 1999).

The first step in the guideline development process is the identification of a substance for consideration for guideline development. In identifying substances to be considered for inclusion in the GCDWQ, the CDW utilizes a multiple rating system based on frequency and concentration of detection in Canadian drinking water supplies, expected health effects and professional judgment. In order for a substance to be considered, the following criteria must be met (Health Canada, 1999):

1. exposure to the substance may lead to adverse health effects;
2. the substance is frequently detected or could be expected to be found in a large number of Canadian drinking water supplies; and
3. the level at which the substance has been detected, or could be expected to be detected, is of possible health significance.

If the above criteria are met, it is determined if a guideline is required. A guideline is considered to be required if it can be established that controlling the substance has "clear potential, based on sound research evidence, to significantly improve population health and reduce disparities" (Health Canada, 1995). In order to establish this, the availability of published literature and national field monitoring data is determined and CDW members assess availability of provincial data. CDW members also identify other relevant information (*i.e.*, toxicity measurements, cost information, economic statistics) that may assist in the assessment and possible guideline development process. At this stage, Health Canada may also begin consultation with other jurisdictions such as the

World Health Organization (WHO) or United States Environmental Protection Agency (U.S. EPA).

The second step in the drinking water guidelines development process involves the scientific assessment of the health risks associated with exposure to the specific substance via drinking water. The availability of adequate toxicological and epidemiological data is verified, a comprehensive literature and data search is conducted and available information is critically reviewed. The WQHB then prepares a draft guideline document which outlines the expected health effects associated with the substance, anticipated Canadian exposure to the substance, the exposure likely attributed to drinking water, existing analytical/treatment techniques and capabilities and a recommended numerical guideline value (Health Canada, 1995 and 1999). The draft guideline document undergoes internal and external review prior to submission to the Standards and Guidelines Ruling Committee of the Safe Environments Directorate to ensure it is scientifically sound and in keeping with government policies on health risk assessment (Health Canada, 1999).

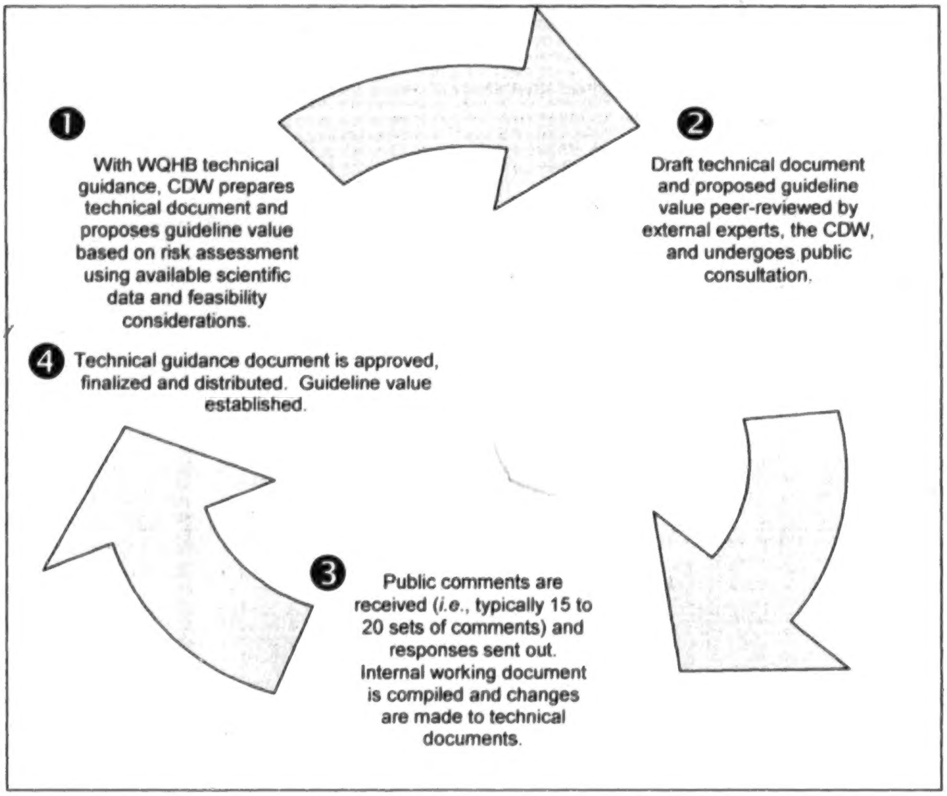
The third step of the guideline development process involves evaluating the feasibility of implementing the recommended guideline in consideration of available treatment/analytical technologies and cost and socio-economic factors. Jurisdictions concerned that their populations may be exposed to drinking water containing the substance of concern at concentrations exceeding the proposed guideline value may estimate the costs for water treatment plant improvements weighed against the benefits of reducing exposure to the substance via drinking water. Based on this information, CDW members provide input on the feasibility of implementing the guideline within their jurisdiction and identify any outstanding concerns they may have (Health Canada, 1995 and 1999).

The CDW then makes the draft guideline technical document available for public consultation to solicit comments on the proposed guideline, on the approach used for development, and on the potential economic costs of implementation, as well as to determine the availability of additional exposure data (Health Canada, 1999). Following the consultation period, a report summarizing the comments received and the decision of the CDW is sent to all participants and posted on the Health Canada website along with the revised document.

Following the feasibility evaluation and public consultation, the CDW members make a final decision and prepare a recommendation. Once a consensus has been reached and CDW members are satisfied with the proposed guideline value and the supporting technical document, CHE provides final approval and it is reported to the ACPHHS. Following approval, a public announcement concerning the proposed drinking water guideline is made available to all CDW members. Each CDW member is responsible for the release of this statement within his or her own jurisdiction. The new guideline is included in the *Guidelines for Canadian Drinking Water Quality – Summary Table* and published on the Health Canada website (Health Canada, 2008). This summary table is updated annually, if required. The guideline is also included in the *Guidelines for Canadian Drinking Water Quality* booklet, intended to be up dated every two or three years. However, it should be noted that the most recent version of this booklet, the 6th edition, was published in 1996.

That last element of the guideline development process is the on-going re-evaluation of existing guidelines. Health Canada is responsible for identifying outdated guidelines. However, any CDW member or other interested party may identify any guideline that may require re-evaluation due to the availability of new research, monitoring data, analytical methodologies or treatment technologies (Health Canada, 1999).

Figure 2. Overview of Guideline Development Process



❶ With WQHB technical guidance, CDW prepares technical document and proposes guideline value based on risk assessment using available scientific data and feasibility considerations.

❷ Draft technical document and proposed guideline value peer-reviewed by external experts, the CDW, and undergoes public consultation.

❸ Public comments are received (*i.e.*, typically 15 to 20 sets of comments) and responses sent out. Internal working document is compiled and changes are made to technical documents.

❹ Technical guidance document is approved, finalized and distributed. Guideline value established.

2.1.2 Guideline Value Derivation

As indicated above, Health Canada is responsible for preparing health risk assessments to derive numerical guideline values for contaminants in drinking water. The *Approach to the Derivation of Drinking Water Guidelines* provides details regarding risk assessment methods employed by Health Canada to derive numerical guideline values for drinking w0ater quality (Health Canada, 1999). The approach used to establish individual MACs may also be described within individual technical guidance documents for specific parameters. It should be noted that current guideline development initiatives are not necessarily consistent with the derivation process outlined in Health Canada's 1999 publication as this document has not been updated to reflect recent improvements or changes to risk assessment methodology currently used by Health Canada.

2.1.2.1 Microbiological Parameters

Microbial pathogens that can commonly occur in drinking water include protozoa, bacteria and enteric viruses. For some waterborne pathogens, one infectious unit can result in illness. Therefore, to protect sensitive subpopulations, it is generally assumed in risk assessment that infection will result in illness. Health Canada assumes that there is no tolerable lower limit for the concentration of waterborne pathogens in drinking water (Health Canada, 1999). However, because the desired goal of zero risk of illness from waterborne pathogens is rarely technically and economically feasible, microbial risks that are considered to be "acceptable" have been derived for some pathogens in drinking water based on the determination of a level of risk that is considered acceptable. Turbidity is presented within the microbial guidelines as a health-based MAC because clusters of microbes or suspended matter in water may interfere with the effectiveness of disinfection and significantly impact drinking water quality by promoting microbial growth and harbouring pathogens (Health Canada, 2003).

Due to numerous challenges and impracticalities associated with monitoring for the presence of every pathogenic organism, surrogates or indicator organisms are typically used to represent the presence of individual pathogens (Health Canada, 1995). As such, specific MACs for microbial parameters have only been established for two microbes *Escherichia coli* (*E. coli*) and total coliforms. Evaluating the presence of indicator organisms is only one part of ensuring microbiologically safe drinking water. Adequate treatment technologies that achieve the required reduction and/or inactivation of pathogens and watershed or wellhead protection measures are also recommended within the GCDWQ (Health Canada, 2008).

2.1.2.2 Chemical and Physical Parameters

Numerical guideline values for chemical and physical parameters are either health based and listed as a MAC, based on aesthetic considerations and listed as an aesthetic objective (AO) or established based on operational considerations and listed as an operational guidance value (OG). The methods used to develop health-based guideline values ensure that the established values are far below (*i.e.,* 10 to 10,000 times) exposure levels at which any adverse health effects have been observed (Health Canada, 2008). As such, exposure to a chemical or physical parameter in drinking water at the recommended guideline is not expected to have an adverse impact on health, and ingestion of water with concentrations slightly exceeding the MAC for a short time is not necessarily hazardous to health (Health Canada, 1999).

For the derivation of numerical guideline values, chemicals can essentially be divided into two categories: 1) those that exhibit a threshold or non-carcinogens – it is believed that there is a dose below which adverse effects will not result from exposure; and 2) those that are non-threshold or carcinogenic – it is believed that there is some probability of an adverse effect at exposure to any concentration of the substance. For chemicals that exhibit both types of responses, the guideline is based on the approach that leads to the most stringent guideline value. The general formulas used to derive numerical guideline values for each of these categories are summarized in Figures 3 and 4.

In general, health-based guideline values are established through the evaluation of data from toxicological studies using animals and occasionally, human epidemiological studies. Results of animal studies are used to derive a no observed adverse effects level (NOAEL) or lowest observed adverse effects level (LOAEL) or a cancer slope factor for the parameter being tested depending on the toxicological classification of the substance. This data, default exposure parameters, uncertainty factors (UF) and other assumptions are used to derive a tolerable daily intake (TDI) and corresponding health-based numerical guideline values for non-carcinogens (threshold substances). Through the application of an incremental lifetime cancer risk (ILCR) that is considered to be negligible and the use of a mathematical model and other assumptions, health-based guideline values for carcinogens (non-threshold substances) are derived.

Following the determination of the recommended health-based guideline value, additional consideration is given to analytical feasibility and the availability of current treatment options prior to establishing the MAC. The established MAC must be achievable by currently available water treatment methods at a reasonable cost and must be reliably measured by available analytical methods (Health Canada, 1999).

Figure 3. Formula Used to Derive Guideline Values for Non-carcinogens or Threshold Substances.

$$\text{Health-based Numerical Guideline Value} = \frac{\text{TDI (mg/kg bw -day)} \times \text{BW (kg)} \times \text{P}}{\text{C (L/day)}}$$

Where:

TDI (mg/kg bw -day) = amount of substance in drinking water that can be ingested daily over a lifetime without appreciable health risk

= NOAEL or LOAEL (mg/kg bw -day)/UF

BW (kg) = average adult body weight (assumed to be 70 kg)

P (no units) = allocation factor; fraction of TDI allocated to drinking water

C = daily intake of drinking water (L/day) or total exposure contribution through drinking water (Leq/day)

Figure 4. Formula Used to Derive Guideline Values for Carcinogens or Non-threshold Substances.

$$\text{Health-based Numerical Guideline Value} = \frac{\text{ILCR } (1 \times 10^{-6} \text{ to } 1 \times 10^{-5}) \times \text{BW (kg)}}{\text{CSF (mg/kg bw -day)}^{-1} \times \text{C (L/day)}}$$

Where:

ILCR = incremental lifetime cancer risk (1×10^{-6} to 1×10^{-5})

BW = average adult body weight (assumed to be 70 kg)

CSF (mg/kg bw -day)$^{-1}$ = cancer slope factor determined using a mathematical model and converted to a human equivalent using scaling

C = daily intake of drinking water (L/day) or total exposure contribution through drinking water (Leq/day)

AOs are established for those parameters that are not considered to pose a health risk at the range of concentrations found in drinking water. AOs are based on information such as taste and odour thresholds and other considerations that may impact the consumer's acceptance of drinking water (*i.e.*, staining, corrosiveness, turbidity and colour). OGs are set for parameters that have the potential to affect processes within a treatment plant or water quality in the distribution system, based on scientific knowledge and current treatment technologies (Health Canada, 1999).

2.1.2.3 Radiological Parameters

Health-based radiological guideline values for drinking water are generally developed using international radiation protection methodologies that take into consideration both background sources of radiation exposure and exposure from drinking water to comprise an annual dose limit (Health Canada, 1995). Recognizing that exposure from drinking water only contributes a small portion to total exposure, MACs for radionuclides in drinking water have been derived based on a committed effective dose of less than five percent (%) of the expected average annual background dose of 2.6 millisieverts (Health Canada, 1995). Additional details pertaining to the derivation of radiological guideline values can be found in the guideline documents.

2.1.3 Current Guidelines

The most recent version of the GCDWQ are available on Health Canada's web site and are summarized in *Guidelines for Canadian Drinking Water Quality - Summary Table* (Health Canada, 2007a). Drinking water quality guidelines are available for microbiological, chemical, physical and radiological parameters, with the highest priority guidelines being those pertaining to microbiological water quality. The GCDWQ summary table is prefaced by stating: "Any measure taken to reduce concentrations of chemical contaminants should not compromise the effectiveness of disinfection." (Health Canada, 2007a). For ease of reference, the GCDWQ, excluding radiological parameters, are summarized in Appendix A. For additional details, please refer to the guideline documents referenced herein.

Microbial guidelines are summarized in Appendix A, Table A1. The GCDWQ recommend testing for *E. coli* and total coliforms in all drinking water systems to ensure compliance with their respective MACs listed in Table A1. The number of samples required and the frequency and location of sampling is not prescribed in the GCDWQ and will vary according to the type and size of the system and requirements of a specific jurisdiction. In addition to the microbial guidelines presented in Table A1, general guidance on the issuing and rescinding of boil water advisories is also provided within the GCDWQ (Health Canada, 2007a).

As of March 2007, there are MACs established for 59 chemical and physical parameters, including turbidity. There are both MACs and AOs or OGs established for seven chemical and physical parameters and there are AOs or OGs established for 19 chemical and physical parameters (Health Canada, 2007a). Chemical and physical parameters with established MACs are presented in Appendix A, Table A2. Chemical and physical parameters with established MACs and AOs or OGs are presented in Appendix A, Table A3. Chemical and physical parameters with AOs or OGs are presented in Appendix A, Table A4.

For some parameters, currently available data does not indicate a significant health risk or aesthetic concern at concentrations typically found in Canadian drinking water. Although guideline technical documents are generally available for these parameters, the development of a numerical guideline is not justified. These parameters are listed in Appendix A, Table A5.

Previously established guideline values which are no longer considered necessary are archived by Health Canada. Guidelines may be archived if the specific parameter is no longer found in Canadian drinking water supplies at levels that could pose a health risk, or is no longer registered for use in Canada (*i.e.*, pesticides, herbicides and other chemicals), and for chemical mixtures (*i.e.*, polychlorinated bi-phenols and polycyclic aromatic hydrocarbons) that have been listed individually (Health Canada, 2007a). A list of currently archived parameters is included in Appendix A, Table A6.

2.1.4 Guideline Application

Although the GCDWQ are used by most jurisdictions in Canada as the basis for establishing drinking water quality requirements, they do not have a legislative basis and are not legally enforceable as national standards (Health Canada, 2008). However, some governments have made them legally binding by incorporating them into provincial regulations or operating permits. Five provinces/territories, Alberta, Nova Scotia, Ontario, Quebec and the Yukon, have specifically incorporated the GCDWQ into provincial legislation. A provincial and territorial summary of guideline value application is provided below.

2.1.4.1 Alberta

Legislation pertaining to drinking water safety in Alberta can be found within: the *Public*

Health Act (Government of Alberta, 2000a) and relevant regulations; the *Alberta Environmental Protection and Enhancement Act* (AEPEA; Government of Alberta, 2000b); and the *Potable Water Regulation* under AEPEA (Government of Alberta, 2003). In Alberta, drinking water from large public systems is regulated by Alberta Environment under AEPEA, which makes the GCDWQ legal requirements for public drinking water treatment systems in Alberta.

Operating approvals for water treatment systems are issued by Alberta Environment. These approvals outline requirements for treatment, performance standards, compliance sampling, monitoring and reporting. Physical, microbial, chemical and radiological parameters within any licensed system must, as a minimum, meet the applicable MAC specified in the GCDWQ or an environmental protection order may be issued. If it is believed that "a potable water supply may cause, is causing or has caused an immediate and significant adverse effect on human life or health", an environmental protection order may be issued directing the performance of necessary emergency measures (Government of Alberta, 2003). The *Alberta Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems* provides further guidance for water treatment system operators (Alberta Environment, 2006).

Regional Health Authorities (RHAs) are responsible for the application of the *Public Health Act of Alberta* within their regional boundaries (Government of Alberta, 2000a). The role of RHAs applies to all drinking water systems in the province and to all aspects of safe drinking water production and delivery, if there is a potential health concern. Although a formal relationship is not prescribed in legislation, Alberta Environment and RHAs work collaboratively, as required. The provincial health agency, Alberta Health and Wellness, fills an advisory role with respect to drinking water safety.

2.1.4.2 British Columbia

Legislation pertaining to drinking water safety in British Columbia can be found within: the *Health Act* (Government of British Columbia, 1996), the *Drinking Water Protection Act* (Government of British Columbia, 2001) and the *Drinking Water Protection Regulation* under the *Drinking Water Protection Act* (Government of British Columbia, 2003). The GCDWQ have not been adopted into legislation in the province of British Columbia. Water suppliers are required to provide water that is potable and meets the requirements of the regulations or any operating permit. Potable water is defined in the regulations as "water that meets the standards prescribed by regulation and is safe to drink and fit for domestic purposes without further treatment" and has specific requirements for fecal and total coliforms (Government of British Columbia, 2003).

In accordance with the legislation, the Ministry of Health is responsible for the development and implementation of legislation, policies, and program standards relating to drinking water quality within the province of British Columbia. The ministry encourages consistency across the province, while recognizing the discretionary authority of the local public health officials within RHAs. RHAs are ultimately responsible for protecting the public from waterborne illness. Individual public health officials, including Medical Health Officers (MHO), Drinking Water Officer or others appointed in writing, provide surveillance and monitoring of drinking water systems and administer and enforce the applicable acts and regulations.

2.1.4.3 Manitoba

In Manitoba, the *Drinking Water Quality Standards Regulation* and the *Drinking Water Safety Regulation* under *The Drinking Water Safety Act,* and the *Water Supplies Regulation* under *The Public Health Act* each contain provisions for drinking water safety (Government of Manitoba, 2007b; 2007c; 2002; 2007a and 2006, respectively). Regulations under *The Drinking Water Safety Act* outline requirements for the construction, operation and monitoring of drinking water systems, water system approvals, treatment and water quality standards and monitoring and reporting (Government of Manitoba, 2002, 2007b and 2007c). The *Water Supplies Regulation* specifies requirements for water disinfection and monitoring (Government of Manitoba, 2007a).

In Manitoba the GCDWQ are not fully adopted into the legislation. Manitoba drinking water quality standards for microbiological parameters and physical standards are prescribed in the regulations or may be prescribed within specific operating licenses. Water quality requirements for a limited number of chemical and radiological parameters (arsenic, benzene, bromodichloromethane [BDCM], fluoride, lead, nitrate, tetrachloroethylene, trichloroethylene, trihalomethanes [THM] and uranium) are prescribed in the legislation and additional requirements may be stipulated within operating licenses for individual systems. Any numerical standards for chemical or radiological parameters specified in the legislation or in an operating license must be consistent with the most recent guideline value within the GCDWQ, if any, for that parameter. Water samples must be collected in accordance with the regulations to ensure compliance with the specific water quality standard. The *Drinking Water Safety Regulation* outlines sample frequency, handling and reporting of result requirements (Government of Manitoba, 2007c).

In accordance with *The Drinking Water Safety Act*, to assist in the provision of safe drinking water, an Office of Drinking Water under the Manitoba Water Stewardship has been jointly established by the Ministers of Health and Conservation (Government of Manitoba, 2002). Individuals within the Office of Drinking Water are responsible for monitoring and enforcement activities. The director, a MHO or a Drinking Water Officer may make a drinking water safety order if it is reasonably believed that drinking water poses, or may pose, a health risk. The director or a Drinking Water Officer must obtain the approval of a MHO before making a drinking water safety order that affects the availability of potable water, requires the water supplier to provide an alternate supply of potable water, or addresses an issue relating to the safety of water currently being obtained from the water system (Government of Manitoba, 2002).

2.1.4.4 Newfoundland and Labrador

In Newfoundland and Labrador, although not prescriptive, provisions for drinking water safety can be found within the *Water Resources Act* (Government of Newfoundland and Labrador, 2002b) and the *Health and Community Services Act* (Government of Newfoundland and Labrador, 1995). The Department of Environment and Conservation, the Department of Government Services and the Department of Health and Community Services work together to provide safe drinking water for the province and enforce the applicable acts and regulations (Government of Newfoundland and Labrador, 2005).

The province monitors drinking water quality of all public drinking water systems. The GCDWQ have been adopted as standards for bacteriological parameters and as non-binding objectives for chemical and physical parameters. The Department of Environment and Conservation is responsible for monitoring the chemical and physical characteristics of source and treated drinking water while the Department of Government

Services is responsible for monitoring the microbiological quality of treated drinking and chlorine residuals. Testing requirements are outlined in approved policies or directives, not within regulations (Government of Newfoundland and Labrador, 2002a and 2007).

The minimum parameters for routine chemical and physical water quality monitoring applicable in the province of Newfoundland and Labrador do not include all parameters in the GCDWQ. If there is reason to suspect the presence of certain substances in a water supply system, additional parameters may be added as required by the Department of Environment and Conservation (Government of Newfoundland and Labrador, 2007).

Where results show that the water exceeds a MAC or any AO for any of the specifically listed chemical or physical parameters, the operator of the water supply is required to develop an action plan in consultation with the appropriate authorities to address the issues. If any of the microbiological criteria are exceeded, corrective action must be taken immediately (Government of Newfoundland and Labrador, 2002a and 2007).

2.1.4.5 New Brunswick

In New Brunswick, the *Potable Water Regulation* under the *Clean Water Act,* the *Water Quality Regulation* under the *Clean Environment Act* and the *General Regulation* under the *Health Act* contain provisions for drinking water safety (Government of New Brunswick, 1993; 1989; 1982a; 1982b; 1988a and 1988b, respectively).

The *Clean Water Act* requires owners of public water systems to test the water in accordance with the regulations and allows for the Minster of Health to take action if a significant health risk is posed by drinking water (Government of New Brunswick, 1989). The *Potable Water Regulation* requires water sampling plans, approved by the Minister of Health, to be in place for regulated systems. All newly drilled or re-drilled private wells also require mandatory testing under the regulation (Government of New Brunswick, 1993). The *Water Quality Regulation* under the *Clean Environment Act* requires owners or operators of a source of water to obtain an approval for the construction, operation, or modification of the source and indicates that a person responsible for a waterworks may be required to monitor specific parameters (Government of New Brunswick, 1982a and b). The *General Regulation* under the *Health Act* requires the maintenance of a chlorine residual and the inspection of disinfection equipment and outlines guidance for assessing health risks from drinking water (Government of New Brunswick, 1988a and b).

In New Brunswick, legislation specifies that no water supply shall be used as a potable water supply unless it is of a safe and sanitary quality. The *Water Quality Regulation* defines potable water as "water that is safe for human consumption" and the *Health Act* defines potable water as "water that is suitable, on the basis of both health and aesthetic considerations, for drinking and cooking purposes" (Government of New Brunswick, 1982 and 1988). Every owner of a water system in New Brunswick is required to have the water tested in accordance with a sampling plan that is approved by the Minister of Health. The plan will specify a list of substances, frequency of sampling and other requirements (Government of New Brunswick, 1994).

In New Brunswick, water quality standards are discretionary and there is no specific reference made to the GCDWQ within any of the legislation. The Minister of Health may take action if it is believed that there is a significant health risk due to the presence of a contaminant in drinking water. A significant health risk, when referring to a risk posed by water, means "the presence in water of a contaminant or waste or a class of contaminant or waste, the amount, concentration or level of which, when attained in water by itself or in combination with another contaminant, another waste or any substance, in the opinion of the Minister of Health, endangers the health of a person in the circumstances" (Government of New Brunswick, 1989).

2.1.4.6 Northwest Territories

In the Northwest Territories, the *Public Water Supply Regulation* under the *Public Health Act* contains provisions for drinking water safety (Government of the Northwest Territories, 1990 and 1988). The Department of Health and Social Services is responsible for enforcing the legislation. Environmental Health Officers and MHOs are responsible for ensuring the safety of drinking water. Chemical, physical and microbiological standards are prescribed in the legislation. Although no direct reference is made to the GCDWQ, listed standards are similar to those in the GCDWQ. The legislation requires water samples to be collected for testing as determined by the MHO.

The provincial drinking water quality standards are summarized as follows (Government of the Northwest Territories, 1990):

- Water quality must meet a coliform standard.
- Drinking water should contain no impurity which would cause offence to the sense of sight, taste or smell. Prescribed limits for turbidity, colour and threshold odour should not be exceeded.
- Drinking water shall not contain impurities in concentrations which may be hazardous to public health, should not be excessively corrosive to the water supply system and substances used in its treatment shall not remain in the water in concentrations greater than required by good practice. Specific chemical substances listed in the regulations should not be present in a water supply in excess of the listed concentrations.
- A free chlorine residual of 0.2 milligrams per liter (mg/L) is required.
- Any unnecessary exposure to ionizing radiation should be avoided.

2.1.4.7 Nova Scotia

The ***Water and Wastewater Facilities and Public Drinking Water Supplies Regulations*** under the *Environment Act* requires an owner to ensure that the microbiological, chemical and physical characteristics of their public drinking water supply do not exceed the MAC for substances set out in the GCDWQ (Government of Nova Scotia, 1995 and 2005). The Department of Environment and Labour is responsible for administering the Act and Regulations.

The health-based GCDWQ were adopted as legally binding standards for drinking water quality in Nova Scotia in October 2000 (Nova Scotia Environment and Labour, 2007). Within the Regulations, Section 35 prescribes a 'duty to provide safe drinking water' which is defined as: "An owner must ensure that the microbiological, chemical and physical characteristics of their public drinking water supply do not exceed the maximum acceptable concentration or interim maximum acceptable concentration for substances as set out in the [GCDWQ]" (Government of Nova Scotia, 2005).

The regulations require testing of water for microbiological quality, general chemical and physical quality, disinfection residual, source and treated water turbidity, fluoride concentrations and any other substances, as required by the Minister (Government of

Nova Scotia, 2005). The *Guidelines for Monitoring Public Drinking Water Supplies* published by the Department of Environment and Labour outline specific requirements for sample collection and record keeping (Nova Scotia Environment and Labour, 2005).

Owners of water treatment facilities are required to immediately notify the Department of Environment and Labour if: the public drinking water supply does not meet the microbiological, chemical or physical criteria set out in the GCDWQ; there is an incident of raw water contamination; evidence of an outbreak of waterborne illness exists; cross-connection or negative pressure is suspected; and/or, effectiveness of disinfection is compromised due to high turbidity, equipment malfunctions or high chlorine demand (Government of Nova Scotia, 2005). Following notification, the owner must take corrective action as set out in the *Guidelines for Monitoring Public Drinking Water Supplies* or as otherwise required by the Minister or an administrator (Nova Scotia Environment and Labour, 2005).

2.1.4.8 Nunavut

Microbiological, physical, chemical and radiological requirements for drinking water in Nunavut are outlined in the legislation consistent with the *Public Water Supply Regulation* under the *Public Health Act* (Government of the Northwest Territories, 1988 and 1990).

2.1.4.9 Ontario

Legislation pertaining to drinking water safety in Ontario can primarily be found within the *Clean Water Act* (Government of Ontario, 2006) and the *Safe Drinking Water Act* (Government of Ontario, 2002). Twelve regulations have been enabled under the Drinking Water Act and include several provisions for drinking water safety. With the exception of the *Ontario Drinking Water Quality Standards* (Government of Ontario, 2003), these regulations have not been referenced individually within this summary. More information on the 12 regulations can be obtained from the Government of Ontario.

The *Clean Water Act* is intended to protect drinking water sources and is administered by the Ministry of the Environment. The Act requires the development and implementation of source water protection plans to address risks to water sources and prescribe steps to reduce or eliminate significant threats to source water quality (Government of Ontario, 2006). The *Safe Drinking Water Act*, administered by the Ministry of the Environment, contains provisions for the control and regulation of drinking water systems and drinking water testing to protect human health and eliminate the occurrence of drinking water health hazards (Government of Ontario, 2002). Regulations made under the *Safe Drinking Water Act* outline requirements regarding drinking water systems, testing, water quality standards, drinking water system operator and analyst certification and compliance and enforcement. Standards for drinking water quality have been developed and are included in the *Ontario Drinking Water Quality Standards* regulation. These standards are equal to, or more stringent than the GCDWQ (Government of Ontario, 2002 and 2003).

In 2004, in accordance with the *Safe Drinking Water Act*, the Ontario Drinking Water Advisory Council was established. The Council advises the Minister of the Environment on drinking water standards, legislation, regulations, and issues, to protect Ontario's drinking water. The council is made up of representatives from academia, industry and government with expertise in areas relevant to drinking water safety (*i.e.*, microbiology, toxicology, engineering, utility operations, public health, *etc.*). With respect to drinking water quality standards and testing, the council is to consider issues and make recommendations to the Minister of the Environment, to be considered when establishing and revising requirements under the *Safe Drinking Water Act* (Government of Ontario, 2002).

2.1.4.10 Prince Edward Island

Legislation pertaining to drinking water safety in Prince Edward Island can primarily be found within *The Drinking Water and Wastewater Facility Operating Regulations* under *The Environmental Protection Act* (Government of Prince Edward Island, 1988 and 2004). The Water Management Division is responsible for the Province's drinking water. The division regulates water infrastructure and provides microbial and chemical water testing and engineering advisory services.

Although not legally binding, it is recommended to evaluate water quality monitoring results based on the most recent version of the GCDWQ, and where no such guidelines exist, on the advice of the Chief Health Officer. Drinking water supply system owners are required to collect water samples and have them analyzed in accordance with the regulations. In general, samples must be tested for: 1) the presence of coliform bacteria and *E. coli* at a frequency prescribed in the regulations; 2) a general chemical analysis at least once each year; and, 3) a detailed chemical analysis from each source of supply every three to five years depending on the size of the system (Government of Prince Edward Island, 2004).

A general chemical analysis includes the following parameters: alkalinity, calcium, chloride, copper, hardness, iron, lead, magnesium, manganese, nitrate, pH, potassium, phosphorous, sodium, sulphate, and zinc. A detailed chemical analysis includes, as a minimum, the analysis of the following metals and other inorganic constituents: aluminium, antimony, arsenic, barium, boron, bromate, cadmium, chromium, fluoride, selenium, silver, strontium, uranium and vanadium and organic chemicals: benzene, benzo[a]pyrene, BDCM, bromoform, carbon tetrachloride, chloramines, chloroform, chlorodibromomethane, chlorophenols, dichlorobenzenes, dichloroethane, dichloroethylene, dichloromethane, ethylbenzene, monochlorobenzene, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride and xylenes (Government of Prince Edward Island, 2004).

2.1.4.11 Quebec

In addition to applicable sections within the *Public Health Act* (Government of Quebec, 2001), legislation pertaining to drinking water safety in Quebec can be found within the *Regulation Respecting the Quality of Drinking Water* under the *Environment Quality Act* (Government of Quebec, 1984 and 2005). System operators are required to sample the water supplied to the public in accordance with the manner and frequency prescribed in the legislation. The Department of Sustainable Development, Environment and Parks is responsible for ensuring that system owners provide drinking water that complies with the standards defined in the regulation. The regulations contain specified standards for various microbiological parameters, inorganic substances, organic substances (including several pesticides), radioactive parameters and turbidity. The standards prescribed in the Quebec regulations are comparable to the GCDWQ.

2.1.4.12 Saskatchewan

Legislation pertaining to drinking water safety in Saskatchewan can primarily be found within: *The Health Hazard Regulations* under *The Public Health Act* (Government of

Saskatchewan, 1994 and 2002b) and *The Water Regulations* under *The Environmental Management and Protection Act* (Government of Saskatchewan, 2002a and 2002c). The Ministry of Environment is the primary regulator of municipal waterworks and privately owned waterworks with a flow rate equal to, or greater than 18,000 litres per day. Saskatchewan has developed Municipal Drinking Water Quality Standards and Objectives which mandates legally binding standards for turbidity and bacteriological, chemical, and radiological parameters. These standards are set out in the *Water Regulations* and include numerical guideline values for several parameters included in the GCDWQ (Government of Saskatchewan, 2002c).

The Ministry of Health regulates semi-private waterworks that have a flow of less than 18,000 litres per day and smaller non-municipal pipeline systems (Government of Saskatchewan, 2002b). The RHAs regulate these systems and, although private waterworks are not regulated, RHAs may also interpret water quality monitoring results and provide health-related water treatment advice for private systems. It is estimated that approximately 150,000 people rely on private systems in Saskatchewan. It should be noted that the rural user bears the ultimate responsibility for their water quality.

2.1.4.13 *Yukon*

Legislation pertaining to drinking water safety in the Yukon can be found primarily within the *Drinking Water Regulation* under the *Public Health and Safety Act* (Government of Yukon, 2002 and 2007a). Under parts one and two of this regulation the Yukon Environmental Health Services within the Department of Health and Social Services requires owners of large public drinking water systems and bulk water delivery systems to sample their water in accordance with the regulations. Owners must ensure that microbiological, chemical and physical characteristics of the drinking water do not exceed the acceptable concentration for any health-related parameter set out in the GCDWQ. If a system does not meet the GCDWQ, the owner must notify the MHO. The third part of the regulation remains a guideline and applies to small systems (*i.e.,* less than 15 service connections or five delivery sites if trucked). In accordance with the guidelines, owners of small systems should also ensure that their water is sampled and meets the health based-parameters of the GCDWQ (Government of Yukon, 2007b).

In general, drinking water must be sampled at a frequency prescribed in the regulations and tested for: 1) the presence of coliform bacteria and *E. coli*; 2) turbidity; and 3) THMs each quarter. Although not specified for large systems, small systems require testing for chemical and physical parameters when applying for an initial permit, one year following the application and every five years thereafter, when results indicate a minimal fluctuation between parameters from one year to the next (Government of Yukon, 2007a).

In summary, all owners of drinking water systems in the Yukon are required to supply safe drinking water which is defined as "water that meets the health-related criteria set out in the GCDWQ, and does not pose a health or safety risk to its users". A health and safety risk is defined as "a condition that is or is likely to cause disease, injury and/or illness in humans" (Government of Yukon, 2007a and 2007b).

2.2. Risk Assessment and Risk Management Concepts

There is a considerable body of literature that provides commentary on the variability, uncertainty and resulting limitations of environmental health risk assessment and risk management. A review of a very small sampling of the available literature has been done to briefly introduce risk assessment and risk management concepts and corresponding issues that should be considered when determining the most appropriate risk management strategy for protecting the public from a given health risk. These issues and concepts include:

- Risk assessment and risk management are not the same thing.
- Uncertainty and variability are inevitable limitations of risk assessment that are accounted for through the use of judgments, conservative assumptions and science policies.
- Risk predictions based on risk assessment are very conservative and must be weighted accordingly when used in risk management decision making.
- The quality of data relied upon when making risk management decisions can be subject to errors and omissions.
- Applying a certain level of precaution is an important and justifiable element of public health risk management.

- There is no such thing as zero risk, there are only risk trade-offs.
- Risk management decision making should follow a reasonable set of principles.

Risk assessment and risk management principles are applied around the world in the derivation of numerical environmental health guidelines or standards. Although not without limitations, human health risk assessment can provide us with a systematic approach for characterizing the nature and magnitude of risks associated with environmental health hazards (enHealth, 2002). Risk assessment is most commonly defined as the process of estimating the potential impact of a chemical, physical, microbiological or psychosocial hazard on a specified human population or ecological system under a specific set of conditions and over a specified timeframe (enHealth, 2002). The process generally involves four main steps: 1) issue identification; 2) hazard assessment; 3) exposure assessment; and 4) risk characterization (enHealth, 2002).

Information made available through risk assessment is used to guide decision making during the process of risk management. Subsequently, health risk assessment must be distinguished from risk management. Although closely intertwined, risk assessment and risk management are two separate activities. In simple terms, risk assessment is "what the science tells us" and risk management is "determining what we can do about it", the process by which risk assessment information is used with other information to make regulatory decisions (Patton, 1993).

Uncertainty and variability have long been recognized as inherent limitations of human health risk assessment with significant implications for resulting risk management decisions (U.S. EPA, 2003; Gibb, 2002; Patton, 1993; Hrudey, 2000; Scheuplein, 1993; enHealth, 2002; and Paustenbach, 1995). The U.S. EPA's Human Health Risk Assessment Research Strategy was introduced in 2003 and identified several broad limitations of human health risk assessment (U.S. EPA, 2003; Gibb, 2002). Major limitations associated with evaluating risks to chronic low-level chemical exposures primarily result from uncertainties associated with the use of toxicological data from laboratory studies using animals. There are also other limitations associated with exposure assessment and the use of epidemiological data. The main limitations of environmental health risk assessment include, but are not limited to:

- The dose-response relationship at exposures below the range where effects have been observed in animals or humans is uncertain (U.S. EPA, 2003).

- There is a great deal of uncertainty associated with the extrapolation of toxicological data from animals to humans. Extrapolation from animals to humans assumes similar rates of absorption, activation and elimination and similar metabolic pathways in both species. However, there are several differences in breathing rates, organ sizes, rates of metabolism, rates of cell turnover and life spans (Hertz-Picciotto, 1995). Therefore, researchers can not be certain that the mechanism of action in animals is similar to that in humans (U.S. EPA, 2003).

- Exposure to a substance in a controlled laboratory environment is not representative of real-world exposures. Laboratory exposures usually involve a relatively high dose of a single chemical, using a dose vehicle, for a short period of time administered to one species and sex of test animal (Hatch and Thomas, 1993).

- The variation in response to a chemical substance across the human population as a result of inter-individual differences in susceptibility to disease, pre-existing disease, variations in exposure, diet, lifestyle and other factors may be significant and is not fully understood (Hertz-Picciotto, 1995).

- The total exposure and risk to a single agent from different routes of exposure (*i.e.*, inhalation, ingestion, dermal, *etc.*) is not well measured or understood (U.S. EPA, 2003).

- The combined risk resulting from aggregate exposures to multiple substance, agents or stressors is not well measured or understood (U.S. EPA, 2003).

- Methods used to estimate human exposures to environmental contaminants are relatively simple (*i.e.*, based on averages, *etc.*) and often fail to account for human activity patterns (*i.e.*, migration in and out of affected area) and the rate and duration of exposure (Hatch and Thomas, 1993).

- Exposure assessment does not measure dose, which depends on host characteristics (*i.e.*, age, sex, metabolism) and individual susceptibility (*i.e.*, natural barriers of the body, susceptibility of target tissue, *etc.*), effect of concurrent exposures (*i.e.*, cigarette smoking) and other considerations (Hatch and Thomas, 1993). Only certain elements of the dose may be relevant to health outcomes or be biologically effective. For some chemicals, like byproducts from chlorination, exposure is estimated using surrogate measurements.

- The impact(s) of resulting risk management actions on the health of the population can not be measured and are therefore not known (U.S. EPA, 2003).

- Most commonly, cancer risk assessment used to derive regulatory standards assumes that there will be some risk of developing cancer irrespective of how small the dose. The cancer slope factor is most often derived through the application of a mathematical model that assumes no threshold and is linear at low doses. Available models are strictly theoretical in nature and their use is ultimately a policy decision. The experimental biological validation of the resulting predictions is not possible. Further, if the true dose response is non-linear the model's upper bound estimate may over estimate the risk by several orders of magnitude (Scheuplein, 1993).

- Epidemiological studies do not have the ability to accurately evaluate the levels of risk that are relevant to regulators (*i.e.,* one in one million lifetime risk). However, epidemiological data is often used to support findings of laboratory animal studies or to compliment risk assessment. Environmental epidemiology in general is limited because the risks are likely to be low, difficult to detect and may not be statistically significant (Hatch and Thomas, 1993).

The identification of the above issues has been well documented. However, determining which of these concerns has the most significant implications for risk assessment remains a challenge (Gibb, 2002). For example, the U.S. EPA questions if it would be better to first improve exposure assessment and further evaluate where exposures come from or would it be better to begin evaluating the health effects of a particular chemical? This challenge makes it difficult to prioritize further research initiatives in the area of human health risk assessment (U.S. EPA, 2003). Source of uncertainty and variability that may be introduced within each step of the risk assessment/risk management process are summarized in Table 1.

To account for the numerous uncertainties, conservative assumptions are typically made throughout each step of the risk assessment process. The result is typically an overestimation of the magnitude of the risk. Common conservative assumptions may include, but are not limited to: using data from the most sensitive species tested, assuming no threshold responses for carcinogens and linear low dose extrapolation, making worst-case assumptions regarding exposure, and applying UFs when, for example, using a LOAEL when a NOAEL is not available. This often results in a predicted outcome that is far from reasonable because each conservative assumption is compounded in the final risk estimate (Bogen, 1994).

Table 1. Potential Sources of Uncertainty and Variability in Each Step of Environmental Risk Assessment

Step	Potential Sources of Uncertainty/Variability
Issue Identification	• Difficult to establish a link between exposure and illness • Limited environmental data for several new or emerging substances • Typically, a relatively small population is affected
Hazard Assessment	• Data limitations, particularly with low dose • Scientific uncertainties associated with animal to human extrapolations • Exposures within a controlled laboratory environment for animal studies are not representative of real-world exposures • Unknown or uncertain mechanisms of action • Variation in biological response between and within different species • The use of mathematical models for cancer risk assessment that assume no threshold and are linear at low doses
Exposure Assessment	• Variable human activity patterns (*i.e.*, people may not live in one household for 70 years) • Bioavailability of the substance, determining dose and biologically effective dose • Data collection, practical and conceptual limitations of data • The use of surrogates to represent the presence of a contaminant
Risk Characterization	• Uncertainty with aggregate or cumulative exposures • Varying risk judgements • Varying interpretations of scientific information • Use of data from many different disciplines
Risk Management	• Different interpretations of the risk assessment • Unknown impact on public health • Unknown extent of possible secondary risks that may be introduced

Although options are available to help reduce uncertainty (*i.e.*, improve the models, collect more exposure data, *etc.*), associated costs make these options unfavorable, in consideration of the limited value that any reduction in certainty would add.

In the paper *The ABCs of Risk Assessment*, the author explains that a risk assessment is only as strong as the data that is used to create it. Evaluation of the following qualitative considerations is essential in order to determine the level of confidence in the findings of the risk assessment (Patton, 1993):

- The extent of available data and identification of any existing data gaps
- The availability, quality and use of epidemiological studies and/or experimental animal studies
- The diversity of animal species for which laboratory test data is available (*i.e.*, more than one species tested)
- The similarity of responses in different species of test animals to the chemical tested
- The general scientific uncertainties
- The number and types of assumptions made throughout the risk assessment

Patton (1993) further explains that variability, misunderstanding and controversy are inevitable because available scientific information can be reasonably interpreted in several ways. The use of data from many different disciplines (*i.e.*, chemistry, biology, geology, toxicology, epidemiology, statistics, *etc.*), the variable interpretation of the data, assumptions made to address data gaps and uncertainties and different values, opinions and perspectives will result in very different, yet often equally defensible, estimates of risk.

Varying risk judgments between the public and the scientific community and within the scientific community itself adds another layer of complexity to risk assessment and risk management. Survey results presented by Rizak and Hrudey (2005) demonstrate that divergent interpretations of basic assumptions and concepts in environmental health risk assessment exist between different environmental disciplines (*i.e.*, environmental engineering professors, chemists and environmental epidemiologists). In consideration of the difficulties associated with evaluating and communicating risk, the authors suggest that experts should evaluate their own knowledge and understanding of basic assumptions and concepts in health risk assessment and become fully aware of the strengths and limitations of risk assessment methods (Rizak and Hrudey, 2005).

Scheuplein (1993) highlights several other unique challenges associated with evaluating risks from chemical exposures. In particular, estimates of risk from chemical exposures and estimates of risk from other things like personal activities or natural disasters are very different. The main difference being that most risks associated with exposure to chemicals at concentrations typically found in the environment are not proven, they are predictions based on inferences and extrapolations whereas risks attributed to personal activities (*i.e.,* driving a car) and natural disasters have been demonstrated and recorded from direct experience. Further, chemical risks are average attributed risks that apply to no one individual but rather everyone on the average. Therefore, these risks can only be compared if the differences between them are understood. Scheuplein closes his paper by suggesting that with respect to environmental health risk assessment, the regulatory objective is often fulfilled at the expense of the scientific one: "linear extrapolation of rodent bioassay data embodies the regulator's credo - It's better to be safe than sorry far more than it does the scientist's - It's better to be right than wrong" (Scheuplein, 1993).

The data relied upon when making risk management decisions can be subject to errors and omissions. Therefore, quality assurance and quality control (QA/QC) programs are essential to minimize quality failures. Crumbling *et. al* (2001) propose that a more comprehensive understanding of data quality concepts can improve decision making for site investigation and cleanup projects. Data quality is defined by the U.S. EPA as "all features and characteristics of data that bear on its ability to meet the stated or implied needs and expectations of the customer" (U.S. EPA, 2000). Although this paper addresses data limitations and data quality in the context of contaminated sites, the discussion is relevant for environmental sampling in general and can be applied specifically to drinking water.

Public health risk management decisions typically carry significant social and economic consequences *(i.e.,* expensive, negative impact on public confidence, introduction of secondary risks, *etc.*). Therefore, the limitations of the data upon which these decisions are based must be clearly understood and accounted for, to the extent possible. However, it is still often assumed that analytical data from approved laboratories are free from error and are subsequently termed "definitive data" even though sampling uncertainties can be significant.

Data quality can be influenced at any of the following stages of the sampling and analysis process (Crumbling *et.al.*, 2001): 1) sample selection (sampling program development); 2) sample collection; 3) sample preservation, transportation, handling, storage and sub-sampling; 4) sample analyses, including sample preparation, cleanup, introduction and measurement; and 5) recording, documentation and transmission of results. It is critical to select and collect samples that are representative of the water in the system, within the context of the decision to be made. The largest sources of uncertainty in data are typically issues related to sample collection, specifically sample reresentativeness (Crumbling *et.al.*, 2001). This is particularly true for drinking water samples. If representativeness can not be established, the quality of the monitoring result is irrelevant.

In the paper *Risk Management and Precaution: Insights on the Cautious Use of Evidence*, the authors discuss the limitations of laboratory results when looking for rare hazards (Hrudey and Leiss, 2003). The paper concludes that we need to balance the consideration of the likelihood and consequences of both false positive and false-negative errors in risk management. This is an important insight because in the case of drinking water quality monitoring, health hazards should rarely be present (*i.e.,* harmful substances such as chemicals or coliforms). This means that unless a monitoring method is perfect, the false positive rate will be applied to a dominantly negative sample population making some number of false positive results inevitable. For realistic levels of performance, the positive monitoring results will be predominantly false positives. Through their demonstration, Hrudey and Leiss provide scientific basis for the cautious use of analytical results (2003).

We are no doubt faced with a dilemma when trying to effectively manage risks in the face of uncertainty. An evaluation of issues facing risk assessment and risk management would not be complete without providing commentary on the precautionary principle. Even with the uncertainties, regulators are forced to make environmental risk management decisions to protect public health. These decisions are made by applying the precautionary principle. When the precautionary principle is applied, where there are threats of serious or irreversible environmental damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation (United Nations, 1992). It is reasonable to apply the precautionary principle when, on the basis of the best scientific advice available in the time-frame for decision-making (EC, 1998; United Nations, 1992):

- there is good reason to believe that harmful effects may occur to human, animal or plant health, or to the environment;
- risk can not be assessed with sufficient confidence to inform decision-making because of the level of scientific uncertainty surrounding the consequences or likelihoods;
- both a reason to believe that serious harm is possible and a cost effective option available to mitigate the harm must exist; and
- measures implemented to manage the risk are provisional, pending the results of further research to fill data gaps.

Dorman (2005) argues that the precautionary principle is widely viewed as the centerpiece of public health policy and its application is understandable, if not necessary. It is widely acknowledged that adopting an appropriate degree of precaution is fundamental to risk management. However, the real challenge lies in how precautionary to be in the face of uncertainty (Hrudey and Leiss, 2003).

Zero health risk is not possible. It is only possible for risk management to minimize preventable health risks, not eliminate them. Therefore, risk trade-offs are inevitable in any risk management decision (Hrudey, 2000). A policy example of this is the Delaney clause of the U.S. Food and Drug Act of 1958, which states that no additive will "be deemed safe if it is found to induce cancer when ingested by man or animal" (Vogt, 1992). This language has been interpreted to mean a "zero risk" standard for any cancer-causing food additive, including residues from pesticides found in processed foods. The total ban on synthetic carcinogenic food additives that was intended to be a zero-risk policy actually maintained health risks caused by exposure to older, likely more hazardous, food additives that continued to be used (Vogt, 1992). The policy also gave companies incentive to create non-carcinogenic additives that were potentially more harmful to human health.

While possible, the assumption of a linear, no threshold response in carcinogenic risk assessment is far from certain. Regardless, even if the zero threshold models could be validated, Hrudey and Krewski (1995) argue that within a realistic concept of safety, there is a safe level of exposure to a carcinogen. This argument is made by demonstrating that daily exposure to the smallest measurable amount of the most cancer-causing chemical would pose a *de minimus* risk by even the most cautious standards (Hrudey and Krewski, 1995). This rational analysis is provided in an effort to clarify the boundaries of concern that have been applied to carcinogens. The hope is that, regardless of the model used in carcinogenic risk assessment, scientists will avoid promoting impossible expectations or unwarranted fears that zero risk concepts imply (Hrudey and Krewski, 1995).

Any effort to minimize or reduce one risk will inevitably introduce secondary risks. When making risk management decisions in the interest of public health, the risks *vs.* the benefits of possible alternatives must be carefully considered and the potential risks associated with available alternatives must be evaluated. This evaluation will identify a variety of options with a broad range of acceptable risks with varying implications (*i.e.*, public health, social, political, economic, *etc.*). Therefore, it should be anticipated that public health risk management decision making be an iterative process between evaluation and consideration of the options and possible secondary risks.

Given the limitations of risk assessment, the findings can not be as determinative as we might like them to be. At best risk assessment findings may only provide guidance for making decisions (Hrudey, 2000). In consideration of this reality, Hrudey warns that scientific evidence alone is not sufficient to guide good decision making for society and offers the following ethical principles to guide societal risk management (Hrudey, 2000).

1. Do more good than harm through recognition that trade-offs are inevitable and the quantity and quality of "good" must be weighed against any potential harm
2. Provide a fair process of decision-making
3. Insure an equitable distribution of risk through the consideration of who benefits

and who may be harmed by any risk

4. Seek the optimal use of limited risk management resources
5. Promise no more risk management than can be delivered
6. Impose no more risk than you would tolerate yourself

The above ethical principles are reasonable and fair. However, examples of poor societal risk management due to failure to follow these principles can still be found (*i.e.*, the Delaney Clause presented in preceding paragraphs). For example, many risk assessment experts would agree that the U.S. EPA has promised much more risk management than they can deliver by stating "Quantified benefit estimates for the Stage 2 Disinfection By Product Rule are based on reductions in fatal and non-fatal bladder cancer cases. EPA has projected that the rule will prevent approximately 280 bladder cancer cases per year. Of these cases, 26% are estimated to be fatal. Based on bladder cancer alone, the rule is estimated to provide annualized monetized benefit of 763 million to 1.5 billion dollars." (U.S. EPA, 2005). Given limitations of risk assessment and failure to clearly establish causation or accurately quantify exposure, it is not possible to predict the number of cases of cancer that may result from exposure to disinfection by-products with any degree of certainty. Therefore, the above statement could never be proven.

Risk assessment is complicated and the information used to formulate our predictions of risk has limitations. Therefore, resulting risk management decisions are equally complicated. Assumptions, judgments and resulting scientific policies used to fill data gaps will frequently lead to misunderstanding and controversy. For risk assessment to remain credible data limitations and resulting assumptions (science policies) must be clearly identified and explained. A numerical guideline value is only as credible and reliable as the data used to create it. Therefore, it is important to look behind the process and remember that there are multiple sources of information, several types of scientific analyses, numerous uncertainties, judgments that vary by each individual and policies that vary by jurisdiction (Patton, 1993).

In light of all the criticism, one may be forced to ask if it is possible to do a good environmental health risk assessment. The Government of Western Australia (2006) defines a good health risk assessment as "a process that aims to provide the best and most objective scientific information about the risks of a specific situation". There are key points that are important for the development of a good health risk assessment: transparency, objectivity, consideration of all stakeholder concerns, appropriate consultation, ensuring quality of the data, justification for methodologies, justifications for reference standards and for modeling, relevance of data and models to the situation, clear indication of assumptions and clear indication of limitations and uncertainties (Government of Western Australia, 2006).

2.3. Drinking Water Risk Management

The protection of public health is the ultimate objective of drinking water risk management programs. In recent years, significant water-borne disease outbreaks have prompted a re-evaluation of the way risks to drinking water are managed, resulting in the development of a more holistic approach to the management of drinking water safety. Several papers and articles discussing recent improvements and recommendations for additional improvements to the way drinking water safety is managed have been published. It has been demonstrated time and again that failures in drinking water safety are not a result of inadequate stringency of numerical water quality standards, but rather by oversight and management inadequacies. This realization has prompted the recommendation that total quality management concepts be applied to drinking water.

In the article *Drinking Water Quality – A Risk Management Approach*, Hrudey introduces ten risk management principles that are used to advocate the development of a more comprehensive risk management framework for water quality management (Hrudey, 2001). These concepts have since been further developed and a set of drinking water risk management principles for a total quality management framework have been outlined as (Hrudey, 2004):

- Anticipate and prevent harm rather than just reacting to problems (*i.e.*, do not rely on compliance monitoring alone for assuring safe drinking water)
- Set priorities based on risks rather than hazards (*i.e.*, the list of potential drinking water contaminants is lengthy so focus on those that are most likely to cause the greatest harm to the public)
- Use risk assessment to inform risk management, seeking actions that will achieve

the greatest overall reduction in risk

- Recognize the inevitable role of human behavior, maintain vigilance and fight complacency
- Know your system and convert hindsight into foresight
- Seek leadership and invest in knowledge

The author concludes that if these important principles that comprise a total quality management framework are successfully implemented, future drinking water system failures may be prevented and the drinking water industry can achieve their primary goals: protect public health while providing high quality water at an affordable price (Hrudey, 2004).

The total quality management concepts presented in the articles discussed above, have been incorporated into drinking water regulatory frameworks throughout the world (WHO, 2004; NHMRC, 2004; NZMOH, 2001, 2005a, 2005b). The WHO drinking water guidelines emphasize preventive risk management through a "framework for drinking water safety" that incorporates "water safety plans" (WHO, 2004). The framework promotes preventive approaches over a reliance on the comparison of water monitoring results against numerical guideline values.

In Australia, the National Health and Medical Research Council (NHMRC) has incorporated a "Framework for Management of Drinking Water Quality" into the *Australian Drinking Water Guidelines* (NHMRC, 2004). This framework provides a total quality management approach that incorporates the following

- Being preventive rather than reactive
- Understanding the entire water supply system and the hazards that can impact drinking water quality
- Distinguishing greater risks from lesser ones and developing effective measures to manage significant risks first
- Investing resources in risk management appropriately to maximize the outcomes that are intended
- Taking time to learn from experience

The foundation of this framework is in promoting a complete understanding of the entire water supply system, potential hazards and effective measures to manage potential risks. Through source water protection, optimal treatment and process controls, effective implementation of multiple barriers and maintaining the integrity of the system, greater protection of public health is expected to be achieved (NHMRC, 2004).

New Zealand's Ministry of Health's (NZMOH) revised *Drinking-water Standards* and their *Draft Guidelines for Drinking Water Quality Management* have shifted the focus from 'quality control' to a broader approach of 'quality assurance' (NZMOH, 2005a and 2005b). The 'quality assurance' approach requires drinking-water suppliers to develop "Public Health Risk Management Plans" which systematically assess the requirements for providing safe drinking-water. The requirements of these plans are further discussed in the NZMOH publication *How to Prepare and Develop Public Health Risk Management Plans* (NZMOH, 2001). The main objectives of a risk management plan are to reduce the likelihood of contaminants from entering water supplies and encourage the use of risk-management principles during treatment and distribution so that monitoring of finished water is not the only water quality management technique employed (NZMOH, 2001).

In Canada, *From Source to Tap: Guidance on the Multi-Barrier Approach to Safe Drinking Water* introduces a preventive risk management approach to drinking water safety (CCME, 2004). The multi-barrier approach consists of three main elements: source water protection, drinking water treatment and drinking water distribution system. However, the multi-barrier approach in Canada does not appear to be as robust as programs implemented elsewhere and it is not clear how this document fits into the overall framework for assuring the safety of Canadian drinking water supplies relative to other guideline documents. Although the document appears to be a good source of information, it offers little in the way of practical guidance or tools for those with responsibility for providing safe drinking water.

Historically, monitoring of drinking water quality has been relied upon as primary evidence that water is safe to drink. Several published papers introduce concepts pertaining to the limitations of environmental monitoring data and specifically, the limitations of end-of-tap drinking water monitoring. General concepts pertaining to limitations of environmental monitoring data were introduced in the preceding section.

Australia's Cooperative Research Center for Water Quality and Treatment published a research report, *Strategic Water Quality Monitoring for Drinking Water Safety* (Rizak and Hrudey, 2007a). The report highlights the common misconception that treated drinking water quality monitoring to demonstrate apparent compliance with numerical guideline values is the primary means of assuring safe drinking water. In reality, the report states that the most effective way of ensuring the safety of drinking water, at least to the extent possible, is through a comprehensive risk management approach.

The effective design and implementation of water quality monitoring programs is a component of a broader, more holistic, risk management approach to drinking water safety. Monitoring programs should be designed with the goal of continually improving the understanding of a water supply system and the risks the system faces. To do this, monitoring programs need to be developed in consideration of system-specific evidence while recognizing the inherent limitations of sampling and monitoring data. A more intimate linkage between treatment system operations and public health protection must be provided (Rizak and Hrudey, 2007a). A strategic water quality monitoring system is described as "an integrated program of source water, process control and event-driven monitoring supplemented with verification of prevention programs and monitoring of consumer satisfaction" (Rizak and Hrudey, 2007a p.55).

It is concluded within the report that if the limitations of monitoring are recognized and effective drinking water monitoring programs are designed to support risk management decision making, the interpretation of monitoring data should be enhanced. This will result in improved public health decision making. It is stressed that appropriate recognition and support by means of revisions to national guideline programs is required to realize the suggested changes in monitoring strategies for greater public health protection: "For as long as the primary emphasis on compliance monitoring of treated drinking water quality is perpetuated through regulation, many of these additional aspects will not get the focus and attention they deserve, nor adequate resources devoted to them" (Rizak and Hrudey, 2007a p.59).

In 2007, the WHO published a book entitled *Chemical Safety of Drinking Water:*

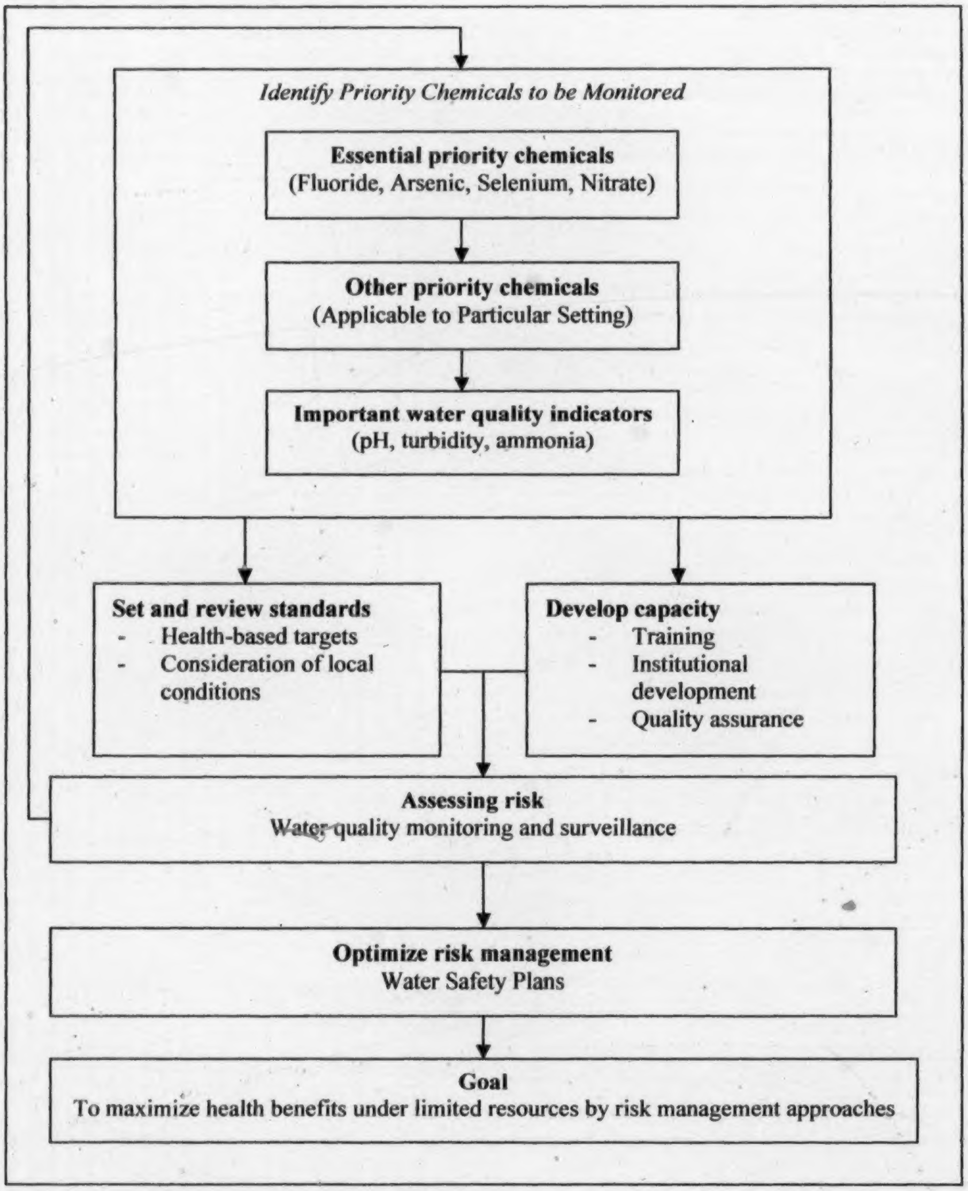
Assessing Priorities for Risk Management (WHO, 2007). This publication has been prepared as a supporting document to the most recent version of the WHO Guidelines for Drinking Water Quality (WHO, 2004). Recognizing that contamination of drinking water from chemicals can pose a serious health risk, the objective of the publication is intended to provide general guidance on prioritizing chemicals in drinking water for risk management, including practical information on the identification of specific chemicals that may be of concern in specific water supply systems (WHO, 2007).

Reliance on water quality monitoring of drinking water to identify potential threats to human health has many limitations. Drinking water quality monitoring results should not be relied upon exclusively to evaluate the safety of drinking water. According to the WHO, the effective preventive management of chemicals in drinking water requires (WHO, 2007):

- distinguishing the few chemicals of local concern from the large number of chemicals of possible concern and prioritizing them; and
- ensuring the appropriate allocation of limited economic resources towards the monitoring, assessment and control of the chemicals that pose the greatest health risks.

The WHO's risk management strategy for the identification of priority chemicals is presented in Figure 5 (WHO, 2007). Using guidance provide by the WHO the probability that specific chemicals may be present in water can be determined. These chemicals may be categorized into four categories: 1) naturally occurring chemicals; 2) chemicals from agricultural activities; 3) chemicals from human settlements; and 4) chemicals from water treatment and distribution. Once the priority chemicals are identified, a risk management plan should be established and implemented to provide a framework for the prevention and reduction of these chemicals. Appropriate monitoring programs are established based on the broad risk management plan (WHO, 2007).

Figure 5. WHO Overall Risk Management Strategy for the Identification of Priority Chemicals


Identify Priority Chemicals to be Monitored
Essential priority chemicals
(Fluoride, Arsenic, Selenium, Nitrate)
Other priority chemicals
(Applicable to Particular Setting)
Important water quality indicators
(pH, turbidity, ammonia)
Set and review standards
- Health-based targets
- Consideration of local conditions
Develop capacity
- Training
- Institutional development
- Quality assurance
Assessing risk
Water quality monitoring and surveillance
Optimize risk management
Water Safety Plans
Goal
To maximize health benefits under limited resources by risk management approaches

2.4. Population Health Perspective

Population health is an approach to health that aims to improve the health of the entire population and to reduce health inequities among population groups. As an approach to health recognized by the Public Health Agency of Canada (PHAC), population health focuses on the interrelated conditions and factors that influence the health of populations over the life span, identifies systematic variations in their patterns of occurrence, and applies the resulting knowledge to develop and implement policies and actions to improve the health and well-being of those populations (PHAC, 1996). In general, a population health approach (PHAC, 1996):

- Uses "evidence-based decision making" to identify priorities and strategies to improve health
- Takes action based on analyses and understandings of the entire range of the determinants of health, recognizing the complex interplay between them
- Recognizes that improving health is a shared responsibility
- Promotes the participation of all Canadians in developing strategies to improve health
- Calls for an increased focus on health outcomes (as opposed to inputs, processes and products) and on determining the degree of change that can actually be attributed to an intervention

The drinking water guidelines program in Canada was reviewed for the WQHB of Health Canada to evaluate the degree to which the program was consistent with a population health model, such that actions arising in the field application of guidelines might result in effective measures for reducing overall population health risk (Hrudey, 2005). This review highlighted several shortcomings in the Canadian approach to the management of drinking water safety. Specifically, the following concepts should be considered when applying guideline values to risk management decision making (Hrudey, 2005):

1. Relying on monitoring for compliance with numerical guideline values is, by itself, insufficient to assure safe drinking water.
2. Establishing guideline values is an exercise in caution. Due to the amount of uncertainty and variability inherent in numerical risk assessment, methods used to develop chemical guideline values ensure that guideline values are far below (*i.e.,* 10 to 10,000 times) exposure levels at which any adverse health effects are expected.

3. Microbial risks to human health are greater than risks posed by chemicals in drinking water. Improved analytical methods have enabled scientists to quantify a wide range of previously-undetected chemicals at extremely low levels (*i.e.*, parts per trillion and lower). As such, there has been growing controversy and increasing alarm over the risks from chemical contaminants in drinking water. However, the most significant risks to people's health from drinking water come from disease-causing pathogens.
4. Not all chemical contaminants should be treated equally. Most of the risks from chemicals in drinking water are associated with only a few key contaminants. Although chemical-related illness does occur, the WHO has identified only a limited number of chemicals with established evidence of causing human health impacts via drinking water. Therefore, chemical guideline values should receive different levels of attention depending on specific local conditions.

The review concluded that a population health perspective reveals the vital role of the guidelines as one of primary prevention. If this is accepted, the importance of the guidelines in preventing exposure that could cause disease may be realized and opportunities for improving the guidelines program and the resulting population health impact may be identified (Hrudey, 2005). Several recommendations are presented by Hrudey (2005) in an effort to move the guideline program in the direction of being truly preventive risk management.

2.5. Relevant Case Examples

2.5.1 Trihalomethanes

Human exposure to trihalomethanes (THMs) is primarily through drinking-water. THMs are formed as a result of a chemical reaction between chlorine, used for disinfection, and organic matter in source water. THMs are one of the main subgroups of disinfection byproducts (DBPs) and they are often used as a surrogate measure for total DBPs. There are several individual THMs, but the most common THMs present in drinking-water are chloroform, bromodichloromethane (BDCM), chlorodibromomethane (DBCM), and bromoform (WHO, 2005). Discussion herein pertaining to the derivation and application of drinking-water guidelines for THMs pertains only to these four compounds.

The toxicity of THMs depends on the specific THM, the route of exposure and the rate and duration of exposure. In general, carcinogenic and non-carcinogenic effects may result from exposure to THMs. Various toxicological and epidemiological studies point towards an association between THMs, particularly brominated compounds and adverse reproductive outcomes including low birth weight, preterm delivery, spontaneous abortions, still-birth and birth defects, although the evidence is not conclusive (Nieuwenhuijsen *et. al.*, 2000). Although direct evidence of human carcinogenicity is limited, there has been some evidence that indicates a possible association between exposure to THMs and cancer of the colon, rectum, brain, pancreas, liver, kidneys and bladder (most consistent association; Villanueva *et. al.*, 2004; WHO, 2005). However, although some studies suggest an association, the data are not conclusive to reliably confirm a dose-response relationship (SENES Consultants Ltd., 2003).

The management of the risks associated with exposure to THMs via drinking water must be done without compromising disinfection. Although potential adverse health risks may result from prolonged exposure to THMs via drinking water, the adverse consequences of consuming disease-causing microorganisms in water are much more certain. With this reality in mind and in consideration of the inconclusive causal relationship between exposure and adverse health outcomes, Health Canada introduced revised drinking water guidelines for THMs in May 2006. The new guideline establishes MACs for total THMs and BDCM (Health Canada, 2006a). The MAC for total THMs in drinking water is 0.100 mg/L, based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system with the highest potential THM levels (Health Canada, 2006a). The MAC for BDCM in drinking water is 0.016 mg/L monitored at the point in the distribution system with the highest potential THM levels. It was concluded that insufficient data were available at the time of guideline development to establish individual guideline values for DBCM or bromoform (Health Canada, 2006a).

2.5.1.1 Total THM Guideline Value Derivation

The total THM guideline value was determined based on risk estimates for chloroform. Chloroform is the THM most often present and usually found in the highest concentration in water supplies (WHO, 2005). Therefore, it is typically used as an indicator chemical representative of the entire THM mixture. For the purposes of the Health Canada risk assessment, chloroform was classified as possibly carcinogenic to humans. As chloroform is not expected to have a mutagenic mode of action it is assumed that there is a threshold below which no cancer is observed. As such, the MAC was derived based on the determination of a threshold level in humans, or TDI by applying an uncertainty factor to the LOAEL. The health-based target for THMs was then calculated using the parameters presented in the following table.

Table 2. Toxicological and Exposure Parameters used in the Derivation of the Total Trihalomethane Guideline Value.

Uncertainty Factor	LOAEL (mg/kg bw per day)	TDI (mg/kg bw per day)	Allocation Factor	Body Weight (kg)	Water Consumption Rate (L-eq/day)
2,100	13	0.0062	0.80	70	4.11

In the derivation of the total THM guideline value, consistent with their derivation process, Health Canada considered specific uncertainty and exposure factors such that a "margin of safety" exists around the established guideline (Health Canada, 1995). Due to the poor quality of the study used in the derivation of the total THM guideline, there is significant uncertainty and variability which are reflected in the use of a relatively large UF of 2,100. The health-based target was calculated based on the observation of a subtle toxic endpoint (increased risk of fatty cysts in the liver) in a small number (48) of adult dogs exposed to relatively high concentrations of THMs via gavage dosing with a toothpaste base in a capsule for a relatively short exposure period (7.5 years). In consideration of this, an UF of 2,100 was applied to account for interspecies variation between dogs and humans (10x), intraspecies variation amongst the human population (10x), less-than-lifetime exposure in the study selected (7x), and, the use of a LOAEL instead of a NOAEL (3x), because of the subtle end-point observed (Health Canada, 2006a).

In an effort to account for all exposures from drinking water, the water consumption rate was adjusted to an equivalent exposure volume (L-eq per day). Exposure to THMs through inhalation and dermal absorption due to volatilization from tap water used for various household activities (*i.e.*, showering, washing, bathing, *etc.*) has been considered in addition to exposure via ingestion (Health Canada, 2006a). Historically, Health

Canada has generally used a default average drinking water intake of 1.5 L per day and the allocation factor that was used was considered sufficient to account for additional routes of exposure (Health Canada, 1999).

Based on the results of the numerical risk assessment, the health-based target was determined to be 0.08 mg/L. However, it was concluded that meeting a guideline value of 0.08 mg/L for total THMs in drinking water may present significant financial implications for water providers and a MAC of 0.10 mg/L was approved (Health Canada, 2006a).

2.5.1.2 BDCM Guideline Value Derivation

In general, brominated THMs are considered to be more toxic and of greater health concern than chlorinated THMs (Health Canada, 2006a). Therefore, drinking water with a higher concentration of brominated THMs may be of greater concern than those with chlorinated THMs even though the total THM concentrations may be similar. Therefore, although BDCM is included in the concentration of total THMs, a separate guideline for BDCM was deemed necessary by Health Canada (Health Canada, 2006a). BDCM is classified as a probable carcinogen and is considered to be weakly mutagenic (WHO, 2005).

The risk estimates used to derive the BDCM guideline value were primarily based on a National Toxicology Program (NTP), 2-year cancer study that involved administering BDCM in corn oil to 50 male and 50 female rats by gavage (NTP, 1987). The resulting animal dose-response data were converted to appropriate human estimates using a robust linear extrapolation model and the application of an allometric scaling factor (Health Canada, 2006a). The guideline for BDCM was established based on an increased cancer risk of one in 100, 000 people over a lifetime exposure and a drinking water consumption rate of 3.55 L-eq/day for a 70 kg adult. The estimated unit lifetime human cancer risk associated with the ingestion of 1 microgram per liter (μg/L) of BDCM in drinking water ranges between 2.06×10^{-7} and 6.33×10^{-7}. The corresponding concentrations in drinking water, considered to be acceptable are between 15.8 and 48.5 μg/L. Selecting the most conservative value, a MAC of 16 μg/L was established. It should be noted that given the significant uncertainties involved with guideline value derivation, the calculation of a MAC, to two significant figures is not appropriate.

2.5.1.3 THM Guideline Values in other Jurisdictions

In addition to Health Canada, there are a number of jurisdictions around the world that have published drinking water guideline values for THMs. In many cases the same toxicity information/studies available at the time of guideline development are used. However, varying judgment used in the selection of different toxicological and/or exposure parameters has resulted in the derivation of different guideline values. For comparison purposes, drinking water guideline values for THMs are presented in Table 3. In summary, the range of acceptable concentrations of total THMs in drinking water throughout the world are between 0.25 and 0.08 mg/L.

2.5.1.4 Limitations of THM Guideline

Limitations of the THM guideline include, but are not limited to:

- There is a large amount of uncertainty in the derivation of the total THM guideline value. An UF of 2,100 has been used to account for these uncertainties.
- The guideline values for both total THMs and BDCM are very conservative as a result of several individual conservative assumptions being compounded in the final risk estimate.
- Uncertainty associated with the determination of a drinking water consumption rate of 3.55 L-eq/day based on one study using generic modeling.
- Due to the complex chemical mixture of DBPs, there is insufficient established evidence that links exposure to individual THMs to adverse health outcomes. An international expert panel has advised that: "total THMs are used in epidemiologic studies as a surrogate for exposure to chlorinated DBPs more generally. The complexity of DBP mixtures in drinking water makes the assignment of causation to any single component or class of components extremely difficult" (SENES Consultants Ltd., 2003 p.2-15).
- The BDCM guideline value was determined using toxicological data from one study that evaluated intestinal cancer in rats (NTP, 1987). A more recent, peer reviewed scientific study conducted by the U.S. NTP did not confirm a causal relationship between BDCM exposure and cancer effects (NTP, 2006).

Table 3. Drinking Water Guideline Values for Trihalomethanes

Jurisdiction/ Agency	Drinking Water Guideline Values (mg/L)				
	Total THMs	Chloroform	Bromoform	DBCM	BDCM
U.S. EPA (2002a)	0.08	-[1]	-	-	-
Australia (NHMRC, 2004)	0.25[2]	0.25	0.25	0.25	0.25
Health Canada (2006a)	0.1	-	-	-	0.016
WHO (2005)	Guideline values have been established separately for all four THMs	0.3[3]	0.1	0.1	0.06[4]
European Union (The Council of the EU, 1998)	0.1	-	-	-	-
New Zealand (NZMOH, 2005a)	The sum of the ratio of the concentration of each THM to its respective acceptable value should not exceed one.	0.2	0.1	0.15	0.06

Notes

1. Guideline values for individual THMs currently under review.
2. Based on health considerations, the concentration of THMs, either individually or in total, in drinking water should not exceed 0.25 mg/L. THM concentrations fluctuating occasionally (for a day or two annually) up to 1 mg/L are unlikely to pose a significant health risk.
3. 0.3 mg/L represents an increase from the previous guideline value of 0.2 mg/L resulting from the increase of the allocation of exposure in drinking water from 50% to 75%.
4. Although the most conservative risk-based guideline value for BDCM in drinking water was determined to be 21 μg/L, the previous guideline value of 60 μg/L was retained as there was no scientific basis on which to justify a change in the guideline value and a concentration of BDCM below 0.05 mg/L may be difficult to achieve using currently available technology without compromising the effectiveness of disinfection.

- The BDCM MAC applies to a one time exceedance due to concerns associated with adverse reproductive outcomes. However, the MAC was established based on its classification as a carcinogen using a study of intestinal cancer in rats.
- The scientific evidence linking reproductive effects to BDCM exposure, which was considered in the determination of the MAC, and is the justification for

applying the MAC to one-time exceedances is open to question.

- The overall quality of the studies upon which the MACs are based are poor for a number of reasons.
- In consideration of the uncertainty involved, the determination of a MAC for BDCM, to two significant figures is not appropriate.

In general, the process used in establishing the MACs for total THMs and BDCM seems to lack transparency and is inconsistent. Ultimately, any effort to reproduce the findings would be difficult because justification and objective rationale is not provided for several of the assumptions that have been made. For example, rationale for the selection of the specific UFs is not provided for the total THM risk derivation and the robust linear extrapolation model used for the BDCM cancer risk assessment is not explained and can not be validated. When clarification was requested during the public comment process, Health Canada responded by saying "The establishment of the MAC was a risk management decision made by the [CDW], based on risk assessment and represents a trade-off between achievability, practicality, feasibility and cost" (Health Canada, 2006b). It is important to note that this specific response and other ambiguous responses referring to commonly accepted risk management practices were used by Health Canada in response to several public comments received.

2.5.1.5 Implications of THM Guideline for Public Health

The development of the guidelines for THM and BDCM are not based on any current or historic evidence linking exposure to a significant adverse public health outcome. For those individuals living in communities with elevated THM levels in their drinking water, it is likely that they have been consuming water containing THMs at that level for several years. Therefore, to suddenly declare the water unsafe because the reported THM concentration exceeds a newly proposed guideline value would be an extreme measure. However, even in consideration of the precautionary nature of the guideline value, the drinking water in a small Alberta community was declared unsafe.

On September 14, 2006 a water usage advisory for the hamlet of Rosebud was issued by the RHA (Hickling, 2006a). The advisory was issued as a result of BDCM, reported in end-of-tap water samples at concentrations up to 18 and 19.6 µg/L. The advisory affected 35 households and businesses who were instructed not to drink or prepare food with the water (Hickling, 2006a). The water usage advisory was removed on October 24, 2006 following receipt of reported BDCM concentrations between 6 and 14 μg/L (Hickling, 2006b).

Many knowledgeable individuals within the drinking water industry would conclude that situation in Rosebud escalated beyond what would be considered reasonable. A reasonable risk management approach should allow for the short term exceedance of the guideline value as long as there is continued effort to optimize disinfection and keep THM levels as low as reasonably achievable. Instead, the water was deemed unsafe even though a concentration of 19.6 μg/L is within the acceptable range of 15.8 to 48.5 μg/L deemed to have an essentially negligible increase in cancer risk by Health Canada (Health Canada, 2006a). Using the most conservative unit risk estimate derived by Health Canada and unrealistically assuming that an individual consumes water containing 19.6 μg/L of BDCM everyday for a lifetime, an estimated ILCR of less than 1.3 in 100,000 would be derived. This increase would be negligible relative to background cancer rates and the significance of an increased ILCR of 0.3 in 100,000 is open to debate. This derivation is based on there being a causal relationship between BDCM and cancer, which remains highly uncertain. It is reasonable to conclude that the elevated concentrations of BDCM in drinking water reported over the short duration did not represent a significant public health risk and the unsafe water use advisory was not justified. This is particularly true when the amount of conservatism in the guideline value is taken into consideration. The impacts of the water use advisory on the community can not be measured. However, the owner of a local bed and breakfast was quoted saying that she felt "anxious [about] having to explain to [her] customers why they can't use the water to brush their teeth" (White, 2006). Based on this it is fair to conclude that there was some stress/fear associated with the advisory and this may have an impact on the public's confidence in the water supply.

There was a similar situation in Quebec in which THM levels exceeded provincial standards (0.08 mg/L) for more than a year (Johnson, 2007). Although quarterly water quality monitoring results reported THM concentrations exceeded provincial standards, three of the reported concentrations were reported below the GCDWQ MAC of 0.1 mg/L. However, government officials chose not to inform the public that their drinking water did not meet the national guidelines and the mayor was accused of trying to cover up a problem with contamination of the local drinking water. As a result, two reported telephone calls suggest that the public's level of confidence in the quality of the drinking water was lessened: "A suburban Montreal woman who suffered a miscarriage phoned her municipal water plant and blamed it for the failure of her pregnancy. Around the same time, a man phoned to find out if he could obtain a letter certifying that his drinking water was safe before making a decision on whether to put his house up for sale." (Johnson, 2007).

One of the aims of risk assessment is to increase consistency so that different people assessing similar problems will come to comparable conclusions. Based on the above examples, the THM guideline risk assessment has failed. If another aim of risk assessment is to make the decision process more transparent to promote confidence in the community, industry and scientists about decisions and actions taken (enHealth, 2002), then the THM guideline fails to achieve this aim also.

As indicated above, the chance of developing cancer resulting from exposure to THMs in drinking water is extremely small in comparison to the risk of microbial illness associated with inadequate disinfection. Risk management strategies based on the THM guideline may result in unnecessary 'do not consume" advisories which could have a negative impact on the public's confidence in the safety of their drinking water. The promotion of adverse health impacts from exposure to DBPs may also result in opposition to chlorination of water supplies. This is the reality in several communities across Canada. Over the last several years it has been an ongoing struggle for many public health professionals in British Columbia to convince communities of the importance of chlorinating drinking water.

For a number of years the community of Erickson, British Columbia had been refusing to disinfect its water because of opposition to chlorination. The community's water system, which serves about 2,000 people had tested positive for fecal coliforms repeatedly over the past 10 years and has had two outbreaks of giardiasis (Hrudey and Hrudey, 2004). The water supply had remained on a boil-water advisory for several years. The MHO and other health officials tried for more than eight years to get the community to disinfect the water, maintaining that the current water source posed an unacceptable health risk. Ironically, opponents to chlorination (Click "Science" button at:

www.watertalk.org/wag/index.html) have cited scientific evidence on health risks from chlorination by-products identified in Health Canada publications.

DBPs pose unique issues with respect to the management of risk trade-offs and the introduction of secondary risks. Rizak and Hrudey (2007b) question whether the growing concern for potential dangers from countless trace organic contaminants, particularly those produced by disinfection, has distracted some drinking water personnel from managing the much greater risks posed by microbial contamination.

2.5.2 Benzene

Benzene is a documented human carcinogen and it has been detected in select Canadian drinking water supplies, although available data indicates concentrations of benzene found in drinking water supplies in Canada are generally below 1 μg/L (Health Canada, 2007b). In accordance with their re-evaluation process, Health Canada has re-evaluated the current drinking water quality guideline for benzene and has proposed a revised guideline value of 1 μg/L. The current MAC for benzene, established in 1987, is 5 μg/L (Health Canada, 2007a).

2.5.2.1 Benzene Guideline Reevaluation

Re-evaluation of existing guideline values is an important, on-going process. The availability of new research, monitoring results, improved analytical methods or treatment processes may prompt the revision of a guideline value (Health Canada, 1999). The risk estimates used in the derivation of the benzene guideline value were primarily based on a 2-year cancer study in rats and mice (NTP, 1986) and a standard drinking water consumption rate of 1.5 L per day (Health Canada, 1987a). The available animal dose-response data were converted to appropriate human estimates using a robust linear extrapolation model. The newly proposed guideline value of 1 μg/L is based on the same animal study but the model used to estimate dose-response and the drinking water consumption rate have been revised (Table 4; Health Canada, 1987a and 2007b):

Table 4. Revised Information Used in Benzene Guideline Re-evaluation

Guideline	Dose-Response Extrapolation Model	Consumption Rate	Unit Risk Range associated with ingestion of 1ug benzene/L
Current 5 µg/L	Linear extrapolation model incorporating a surface area correction from rodents to humans	Standard 1.5 L/day for 70 kg Adult	6.1×10^{-7} to 6.7×10^{-6}
Proposed 1 µg/L	Linearized multi-stage (LMS) model with scaling factor to correct for differences in metabolism between animals and humans	Modified to account for absorption by inhalation and through the skin 4.0 L-eq/day	1.14×10^{-6} to 4.85×10^{-6} Note: the U.S. EPA documentation for the LMS model specifies that no more than one significant figure should be used with LMS risk predictions

In the determination of the revised MAC, the drinking water consumption rate was adjusted to reflect benzene exposure through inhalation and dermal absorption due to the volatilization of benzene from tap water when it is used for washing, showering and other household activities. Health Canada did not specify why the LMS dose-response model was selected to replace the linear extrapolation model previously used and their derivation approach only makes mention of the "robust linear extrapolation model" (Health Canada, 2007b and 1995). However, it is assumed that the LMS model was selected as it is currently the most commonly used default cancer dose-response model.

Analytical feasibility was also taken into consideration during the re-evaluation of the benzene MAC. When the MAC of 5 µg/L was established in 1986, the practical quantitation limit (PQL), based on the ability of laboratories to measure benzene, was 5 µg/L. Each laboratory method for analyzing water quality samples has a PQL, which is the lowest concentration of a substance that can be reliably measured within reasonable limits of precision and accuracy. The current U.S. EPA PQL for benzene is 5 µg/L; however, the U.S. EPA has reported some new data that may support the consideration of a lower PQL of 0.4 µg/L (U.S. EPA, 2002b). The MAC for benzene has been lowered on the basis of a PQL of 0.4 µg/L (Health Canada, 2007b). However, it should be noted that following a review of the benzene maximum contaminant level (MCL) in 2002, the U.S. EPA concluded that there was insufficient data on which to base a PQL recalculation (U.S. EPA, 2002b).

2.5.2.2 Benzene Guideline Values in other Jurisdictions

Risk assessment involves estimating human exposure and dose-response. Different approaches are used by agencies to evaluate and extrapolate available data and therefore there are often differences in numerical guideline values established by different agencies. The upper-bound excess lifetime cancer risk that is considered negligible also differs amongst the different agencies but generally falls within one in 10,000 to one in 1,000,000 (Ritter *et. al.*, 2005). Benzene drinking water quality guidelines established by other agencies and the assumptions made are summarized in Table 5. Drinking water guideline values for benzene range between 1 µg/L and 10 µg/L, excluding the California PHG of 0.15 µg/L, as there was no consideration for analytical practicality and treatment feasibility in setting this strictly, health-based goal (OEHHA, 2001).

Table 5. Benzene Guideline Values in Various Jurisdictions

Agency	Guideline Value	Primary Study	Model	Consumption Rate
WHO (2003)	10 µg/L (based on an upper-bound excess lifetime cancer risk of 10^{-5})	2-year cancer study in rats and mice (NTP, 1986)	Robust linear extrapolation model; there was a statistical lack of fit of some of the data with the LMS model (WHO, 2003).	Default 2 L/day for 70 kg Adult
Australia (NHMRC, 2004)	1 µg/L (based on an upper-bound excess lifetime cancer risk of 10^{-6})	2-year cancer study in rats and mice (NTP, 1986)	Robust linear extrapolation model (WHO, 2003).	Default 2 L/day for 70 kg Adult
New Zealand (NZMOH, 2005a)	10 µg/L (based on an upper-bound excess lifetime cancer risk of 10^{-5})	2-year cancer study in rats and mice (NTP, 1986)	Robust linear extrapolation model (WHO, 2003).	Default 2 L/day for 70 kg Adult
US EPA (2002a)	5 µg/L	Plioform Cohort	Direct extrapolation from human inhalation exposure in the workplace to estimate low-dose response through ingestion	Default 2 L/day for 70 kg Adult
Cal EPA[1] (2007)	1 µg/L	unknown	unknown	unknown
OEHHA[2] PHG[3](2001)	0.15 µg/L	Pliofilm Cohort and Chinese Worker Cohort	Poisson regression and linear relative risk models	4.7 L-eq/day

Notes:

1. California Environmental Protection Agency (Cal EPA)
2. Office of the Environmental Health Hazard Assessment (OEHHA)
3. Preliminary Health Goal (PHG): concentration of drinking water contaminants that pose no significant health risk if consumed for a lifetime, based on current risk assessment principles, practices, and methods.

2.5.2.3 Limitations of the Revised Benzene Guideline

There are significant uncertainties associated with the derivation of the revised benzene guideline value. The resulting limitations of the revised guideline value for benzene include, but are not limited to:

- The new guideline value is close to the PQL and therefore may not be reliably measured by available analytical methods. It has been suggested that in order to accurately characterize concentrations in water samples, the PQL of the laboratory methods used should be at least an order of magnitude lower than the applicable water quality standard. Although U.S. EPA data are indicative of a lower PQL, it is not conclusive and considered to be insufficient to support a PQL recalculation at this time (U.S. EPA, 2002b). Further, Health Canada should have determined a PQL based on data obtained from Canadian labs. A large portion of available benzene data provided to Health Canada during the re-evaluation reports detection limits of 1 μg/L or higher. Therefore, unless future detection limits reported by laboratories are lowered, data interpretation will be difficult. The closer the guideline value is to the PQL, the greater the likelihood for false positives, which may prompt unnecessary corrective action.

- Available epidemiological studies were deemed insufficient by Health Canada during the re-evaluation. Therefore, available animal data were extrapolated to the human population. The methods used to estimate dose-response in the human population are based on conservative assumptions; therefore the actual risks at low levels of exposure may be significantly lower than the estimated value.

- There are limitations associated with the animal study used to establish the guideline value (*i.e.,* relatively short, test animals were rats and mice, *etc.*).

- The shape of the dose-response curve at low doses for benzene-induced leukemia is not known (OEHHA, 2001). The current understanding of how benzene causes cancer is unclear and some researchers have suggested that a threshold may exist based on observations of no increase in leukemia rates among benzene workers when exposed to low levels of benzene. Other researchers believe that the true dose-response relationship for benzene-induced leukemia is non-linear at low doses. In fact, some studies have reported the shape of the dose-response curve for benzene-induced leukemia as supra-linear (OEHHA, 2001).

- There are significant sources of uncertainty and variability with respect to the heath effects of benzene exposure (OEHHA, 2001). The toxic effects of benzene vary considerably within individuals and the range of susceptibility within the population can not be accurately quantified. In addition to genetic susceptibilities, dietary and environmental factors may add to the inter-individual variability. Benzene's toxicity is closely linked to its complex metabolism and distribution in the body and the contributions of each metabolite to the overall toxicity of benzene are not known. Other environmental factors (*i.e.*, infection and co-exposures to radiation and other leukemogens) may introduce additional variability (OEHHA, 2001).

- Uncertainty regarding the determination of the drinking water consumption rate of 4 L-eq/day, based on generic assumptions.

2.5.2.4 *Implications of Revised Benzene Guideline for Public Health*

Lowering the guideline value from 5 to 1 µg/L comes with significant effort and associated costs. Therefore, one would assume that the more stringent guideline value comes with tangible benefit to the public. Although, there is an understandable desire to be conservative and precautionary when it comes to public health protection, it must be understood by all stakeholders that the risk estimates used to derive the benzene MAC (and all other MACs), are predictions, not confirmation of what is going to happen. A lower benzene MAC will not necessarily be more effective at managing public health risks associated with exposure to benzene for a number of reasons outlined within this section.

Reported benzene concentrations in Canadian drinking water are generally below the current MAC and available data suggests that benzene concentrations are also below the proposed MAC of 1 µg/L (Health Canada, 2007b). For example, in Alberta 96% of samples collected from treated surface water supplies had reported benzene concentrations of less than 1 µg/L. In Newfoundland, benzene concentrations in samples collected from raw or treated surface or groundwater samples were below the detection limit of 1 µg/L. In Saskatchewan, benzene concentrations in 30 municipal treated surface water samples were reported below 1 µg/L and 91% (34 samples) of treated groundwater samples had reported benzene concentrations below 1 µg/L (Health Canada, 2007b). Based on available data, it is not anticipated that lowering the MAC from 5 to 1 µg/L would have a significant impact on public health because the occurrence of benzene at concentrations greater than 1 µg/L but less than 5 µg/L is rare.

Relative to other sources, drinking water is considered to be a minor source of benzene exposure (Kindzierski and Jackson, 1998). The most common way to be exposed to benzene is by inhaling benzene vapours. Workers involved in the use or production of benzene are the most likely to be exposed to the chemical at high concentrations. In addition to occupational exposures, tobacco smoke, automobile exhaust, gasoline vapours and industrial emissions are the most typical sources of benzene exposures. Benzene volatilizing from contaminated soil or water can also represent a source of inhalation exposure. Based on this, the increased level of environmental health protection resulting from a lower benzene MAC in drinking water would likely be negligible because drinking water is considered to be a relatively minor source of benzene exposure.

It is difficult to establish an association between exposure to benzene in drinking water and population health outcomes because exposures are typically not widespread and other sources of benzene exposure are significant. The largest source of exposure to benzene is via air. If this is the case, ways to minimize airborne concentrations of benzene should be evaluated before lowering the benzene MAC. For example, in Alberta there are no restrictions on the release of hydrocarbon or benzene vapours during soil and/or groundwater remediation activities. In fact, aeration to remediate benzene-contaminated soil has been an acceptable practice. Considering the vast number of petroleum release sites in Alberta, this could contribute significantly to the concentration of benzene in ambient air. Implementing programs to minimize airborne concentrations of benzene should be considered.

Benzene contamination of drinking water is not widespread (Health Canada, 2007b). Rather, benzene contamination of drinking water is usually the result of localized contamination (*i.e.*, fuel spill, pipeline failure, leaking underground storage tank). Considering most utilities monitor for benzene very infrequently, if at all, it is very unlikely that a localized contamination event would be identified through typical water quality monitoring programs. In most cases of localized contamination, the benzene makes the water unpalatable to the consumer before it poses a health risk and customer complaints would be received long before benzene would be detected in the drinking water. Therefore, there is limited value in establishing a guideline value if it is only used as a comparison tool to evaluate water quality monitoring results.

The benzene guideline would be more effective at managing risks to public health if it included more than just a numerical MAC. A more effective guideline would provide system owners with practical guidance and risk assessment tools that can be used to evaluate the susceptibility of the water source or system to benzene contamination. There would be great value in offering guidance and resources to assist system operators in preventing contamination in the first place. The guidelines should ultimately accommodate the types of benzene contamination events that are likely to be encountered in the real world.

Another important consideration is that once a guideline value is published, it is often adopted by regulatory agencies when determining appropriate remedial endpoints for contaminated groundwater that may be intended for domestic use. The remediation of many petroleum release sites is driven by the more stringent required cleanup concentrations for benzene, which are based on its higher toxicity. Therefore, a lower MAC does not only have implications for drinking water safety. Once a MAC for benzene in drinking water is established, there is potential for that MAC to be adopted as a groundwater remediation goal for contaminated sites. The more conservative cleanup goal would result in higher remediation costs and associated effort which may not be commensurate with the significance of the environmental or public health risk and will introduce secondary risks.

In summary, a lower guideline value does not necessarily translate into improved public health. In the grand scheme of things, revising the guideline value from 5 to 1 μg/L will not ensure additional public health protection and even if the lower MAC were to result in improved public health it would be near impossible to measure.

2.5.3 Significance

For both examples provided herein, it could be argued whether either parameter meets the Health Canada criteria for consideration for guideline development in the first place. As previously discussed, for a substance to be considered for guideline development the following criteria must be met (Health Canada, 1999):

a) exposure to the substance may lead to adverse health effects;

b) the substance is frequently detected or could be expected to be found in a large number of Canadian drinking water supplies; and

c) the level at which the substance has been detected, or could be expected to be detected, is of possible health significance.

Further it must be determined that controlling the substance in drinking water has "clear potential" based on sound research evidence to significantly improve population health and reduce disparities (Health Canada, 1999).

The above assessment criteria are wide open to interpretation and debate. For example: What would be considered "frequent detection"? What is "clear potential"? What is sound research evidence? What would be considered a significant improvement to population health or a reduction in disparity? In an effort to continually improve transparency and consistency, these concepts need to be explained. Based on the available body of evidence discussed herein, a reasonable assessment of benzene and THMs for guideline development is summarized in Table 6.

It is recognized that there is little value in arguing whether guidelines for THMs and benzene should have been established in the first place. What is valuable, however, is drawing attention to the fact that there is a great deal of subjectivity involved in all stages of the guideline development process. In order to promote transparency and encourage consistency in the guideline development process, every effort has to be made to provide an objective foundation upon which good science can be used to establish the guidelines. The above assessment is very subjective.

Table 6. Assessment of Benzene and Trihalomethanes for Guideline Development

Assessment Criteria	Benzene	THMs
Exposure may lead to adverse health effects	Animal and epidemiological studies support this	Animal studies suggest a relationship, epidemiological studies have been inconclusive
Frequently detected or could be expected to be found in large number of Canadian drinking water supplies	Not detected in large number of water supplies; not expected as monitoring programs not designed to capture infrequent, localized contamination events	Yes, frequently detected and expected
Found at a level of possible health significance	Established evidence to either support or refute this is available	Established evidence to either support or refute this is available
Clear potential based on sound research evidence to significantly improve population health and reduce disparities through control of substance in drinking water	Current limitations of science and technology make this impossible to determine	Current limitations of science and technology make this impossible to determine

3. Materials and Methods

To meet the study objectives, personal interviews were conducted with public health professionals to collect information on their level of knowledge and understanding about guideline derivation and application and to solicit recommendations for improvement.

3.1. Participant Selection and Recruitment

The objective was to select between 20 and 30 participants for inclusion in the study based on a purposive sampling design. The proposed sample size was judged to be sufficient to explore a range of current views and to capture a reasonable number of relevant case studies of recent experience which may then be analyzed in relation to the health risk evidence that is applicable. Through the course of their job activities, selected participants must use or have used the GCDWQ for the purposes of risk management decision making.

In total 35 public health professionals participated in the study. Twenty-eight participants represented those who apply the drinking water guidelines at the provincial level as drinking water regulators and those who deal with public health issues associated with drinking water at the front line of public health agencies. Individuals solicited for interviews included the following population of public health professionals throughout Canada:

Table 7. Participant Information

Province	Environment	Health	Regional Health Authority	Total
Alberta	1	4	6	11
Saskatchewan	0	1	2	3
British Columbia	0	0	12	12
Ontario	0	0	2	2
Total:	1	5	22	28

In addition, seven representatives from Health Canada were interviewed to represent those who produce the drinking water guidelines. It is important to note that the findings of the interviews conducted with Health Canada representatives are not presented with the results of the remaining interviews. The objective of conducting interviews with Health Canada was to gather background information prior to conducting the interviews with front-line public health professionals. The findings of these discussions have been considered throughout the development and presentation of the research objectives and findings. Select information gathered during these interviews is referenced within the relevant discussions, where appropriate.

3.2. Interview Design

Each interview was expected to be one hour in duration and an audio recording of the interview was collected to ensure the consistent recollection and transcription of responses. Each interview included a mix of standardized, open-ended questions and closed-, fixed-response questions. In most cases, interviews were conducted in person. In situations where it was not possible or practical to meet in person, a telephone interview was conducted. Participants were generally provided the interview questions one to two days prior to the scheduled interview.

An information letter (Appendix B) that provides an overview of the research objectives and methodology was distributed to each participant prior to the start of the interview. Each participant was also required to sign an interview consent form (Appendix C) prior to the start of the interview.

3.3. Interview Questionnaire

The interviews were semi-structured based on the interview questions provided in the following pages and Appendix D.

Section A: Background

A1. Does your current position require you to apply the *Guidelines for Canadian Drinking Water Quality* prepared by Health Canada, to risk management decision making?

A2. How long have you held a position that requires you to apply the *Guidelines for Canadian Drinking Water Quality* to manage public health risks from drinking water? How long have you been in your current position? Do you have any other relevant experience relating to the management of public health risks from drinking water?

A3. Typically, how do you use the *Guidelines for Canadian Drinking Water Quality* in your work? How often do you refer to the numerical guideline values?

A4. Throughout the course of your career have you had to take action (*i.e.*, issue a water usage advisory) due to the presence of a contaminant (physical, chemical, radiological, and/or microbial) in drinking water at concentrations exceeding water quality guideline values? What did this action entail?

Section B: Guideline Development Knowledge

B1. How knowledgeable are you with the process used to establish the *Guidelines for Canadian Drinking Water Quality*? How would you rate your knowledge? (1-do not know what the process is to 5-know and understand the process extremely well)

B2. Are you familiar with the supporting technical documents created by Health Canada for established guideline values? How would you rate your familiarity with the supporting technical documents? (1-never heard of them to 5-know and understand the contents very well)

B3. For the practical application of guideline values, how useful are the supporting technical documents or any other documents published by Health Canada (list any identified)? (1-I have never looked at them to 5- extremely useful, I refer to them almost every time during the application of the guideline values).

B4. What are the major sources of uncertainty in numerical guideline values for chemicals in drinking water?

B5. How is uncertainty pertaining to expected health effects addressed in the *Guidelines for Canadian Drinking Water Quality*?

Section B: Guideline Development Knowledge

B6. The following are examples of uncertainty factors that have been used in Health Canada risk assessments to derive numerical guidelines:

Lead: UF < 2
TCE: UF $= 100$
Antimony: UF $= 300$
THM (chloroform): UF $= 2100$

What do these UFs tell us about the corresponding guideline values?

B7. According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a carcinogen in drinking water may cause cancer in humans?

a) zero
b) at the guideline value
c) unknown exactly, but expected to be at a concentration significantly higher than the guideline value
d) any concentration
e) do not know

B8. According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a non-carcinogen in drinking water may cause an adverse health effect in humans?

a) zero
b) at the guideline value
c) unknown exactly, but expected to be at a concentration significantly higher than the guideline value
d) any concentration
e) do not know

Section C: Risk Management

C1. How would you define "safe drinking water"?

C2. Traditionally, drinking water suppliers and regulators have relied heavily on compliance monitoring to ensure the safety of drinking water. What are the practical and conceptual limitations of compliance monitoring for assuring safe drinking water?

C3. Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion? How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs.* chemical parameters?

Section C: Risk Management

C4. Health Canada has developed numerical, health-based, drinking water quality guideline values for numerous (approximately 64) chemical parameters. Do you think that each of these chemical parameters all warrant the same level of attention? If yes, why? If no, what should the level of attention depend on? Do you think that the *Guidelines for Canadian Drinking Water Quality* are presented in a way that adequately reflects the relative levels of attention that are warranted?

C5. For how many of the parameters included in the *Guidelines for Canadian Drinking Water Quality,* do you think there is established evidence of causing human health impacts via drinking water exposure?

C6. When a water use advisory is issued as a result of a chemical in drinking water at concentrations exceeding the guideline value, secondary risks may be posed. Of the following secondary risks, which ones do you think have the potential to significantly impact public health? Rate the significance on a scale of 1-5 (1=no significance to 5 = very significant). In your opinion, are there any other secondary risks to consider?

	Inadequate personal hygiene (not bathing, not washing hands)
	Inability to cook nutritious meals
	Reduced water intake
	Stress/fear and decreased confidence in water supply
	Re-allocation of limited personal economic resources to purchase alternative, more expensive sources of water
	Not washing produce (fruit/vegetables) prior to eating
	Not cleaning home/office
	Personal injury (*i.e.,* scalding)
	Other ______________________________

C7. How do water advisories impact the public's confidence in the water supply? Is this relevant to protecting the health of the public?

C8. Health Canada's mandate and expertise lies in protecting the health of all Canadians by developing the *Guidelines for Canadian Drinking Water Quality*. How effective are the current guidelines at protecting the health of Canadians within your jurisdiction? How specifically do you know this? What evidence or observations demonstrate this?

C9. Do you think that monitoring to indicate that physical, chemical, microbial, and radiological parameters in drinking water below (within) the current *Guidelines for Canadian Drinking Water Quality* assures safe drinking water?

Section C: Risk Management

C10. Relative to other measures included in a multi-barrier approach to safe drinking water, how important are the specific guideline numbers (MACs) for ensuring safe drinking water?

C11. How much could chemical concentrations exceed a guideline before you would expect to see adverse health effects in the consuming population?

C12. How do you believe the public expects you to implement drinking water guidelines?

C13. Do guideline values as currently presented to the public adequately portray the expected dose-response relationship and corresponding uncertainties?

C14. If you observe an exceedance of a guideline value, what other types of evidence do you look at prior to taking action?

C15. With the development of more guideline values and/or the lowering of current guideline values, what type of responses would you expect to see within the population?

Section D: Comments and Recommendations

D1. In addition to what is already being done, do you have other expectations of Health Canada when it comes to establishing and implementing the *Guidelines for Canadian Drinking Water Quality?*

D2. Are there changes you would suggest regarding how to apply (*e.g.,* shut down a plant based on a single exceedance of any MAC) chemical guideline values to ensure that water quality guideline values provide the most benefit for all and achieve their intended aim?

D3. Do you feel that you have received adequate guidance on the application of water quality guideline values? Who has/should provide this guidance? In what format was/should this guidance be provided? Formal (classroom, web-based) training, guidance documents, communication?

D4. What can Health Canada do or provide to ensure the consistent and reasonable application of guideline values?

D5. Additional Comments:

4. Interview Results

This section presents the interview results and a discussion of the findings.

4.1. Interview Participation

Interviews were conducted between February 14 and July 11, 2007. A total of 20 interviews were conducted in person and eight interviews were conducted via teleconference. One-on-one interviews were conducted with 26 participants and one interview was conducted with two participants together. Interviews generally lasted an average of approximately one-hour and 15-minutes. The longest interview was one-hour and 42-minutes in duration and the shortest interview was completed within 38 minutes. The interviews were kept relatively informal. Although an effort was made to ask each question within the interview questionnaire in a consistent order, the questions were asked according to how the interview developed. Therefore, not every interviewee was asked each question and questions were not necessarily presented in the same order during each interview. Although a consistent effort was made to phrase each question as written in the interview questionnaire, questions were phrased according to what was felt appropriate at the time, drawing on relevant examples from preceding discussions between the interviewee and the researcher. A summary of interview notes and recordings is provided in Appendix E.

4.2. Summary of Results

A question by question summary of interview responses is provided below. Because this was a qualitative study the determination of frequencies and percentages and statistical representation (*i.e.*, minimum and maximum values, median, and mode) of the quantifiable interview responses has been done only to provide a summary overview of the data. The objective of the data analysis and interpretation was to identify common themes or trends, distill out key comments or learnings that have significance to the study question and solicit recommendations. Further statistical analysis of the data is not appropriate for this qualitative study. The flexible interview approach proved valuable in that a large amount of detail was often provided in the responses. In consideration of the broad scope of response data, personal discretion was used in the categorization of responses, where required to facilitate the presentation of results. A complete summary of responses is included in Appendix E.

4.2.1 Section A: Background

The four questions in Section A were primarily asked to ensure that each interviewee met the inclusion criteria and to obtain general information regarding the interviewee's general experience level with managing public health risks from drinking water and the GCDWQ. Section A responses are summarized in Appendix E, Tables E1 through E4.

Question A1. Does your current position require you to apply the *"Guidelines for Canadian Drinking Water Quality"* prepared by Health Canada, to risk management decision making?

A total of 27 of the 28 research participants answered "yes" to this question. One participant answered "no" as the individual is involved in guideline development not in the day-to-day application of the GCDWQ to risk management decision making. Based on the responses, all participants were considered eligible for inclusion in the study.

Question A2. How long have you held a position that requires you to apply the *"Guidelines for Canadian Drinking Water Quality"* to manage public health risks from drinking water? How long have you been in your current position? Do you have any other relevant experience relating to the management of public health risks from drinking water?

All participants provided a response to this question. At the time of the interview, research participants had been in their current positions for an average of just over six years with a median and mode of four years. Participants had between 1.5 and 37 years relevant experience relating to the management of public health risks from drinking water with a median and mode of 15 years relevant experience. Current positions held by participants cover a broad range and are categorized as follows:

- Technical Advisory Role (four participants)
- Public Health Engineer (one participant)
- Manager or Director of Public Health (seven participants)

- Public Health or Drinking Water Officer or Inspector (15 participants)
- Drinking Water Specialist – Environment (one participant)

Question A3. Typically, how do you use the *"Guidelines for Canadian Drinking Water Quality"* in your work? How often do you refer to the numerical guideline values?

This question was asked in an effort to evaluate current uses and frequency of use of the GCDWQ. All participants provided a response to this question. Based on the responses, the primary uses of the GCDWQ can be grouped into three general categories: 1) using the numerical values as a comparison tool for water quality monitoring results; 2) using the guideline and supporting technical documents as a resource or reference; and 3) using the guidelines and supporting technical documents to assist in the development of regional policies and guidance protocols. Most respondents indicated multiple uses for the GCDWQ. Four respondents indicated that their primary use of the guidelines was for the comparison of water quality monitoring results to the numerical guideline values alone. However, the GCDWQ are most commonly used as a resource or reference to assist public health professionals with explaining and justifying action. Seven respondents indicated that they use the guidelines as a basis to establish regional or local policies or protocols. General uses of the GCDWQ are summarized below.

Table 8. Primary Uses of the Guidelines

Use of Guidelines	Number of Respondents
As a comparison tool for water quality monitoring results only	4
As a comparison tool for water quality monitoring results and as a guide/reference	5
As a guide/reference and to assist in policy development	4
As a guide/reference	11
To assist in policy development	2
As a comparison tool, as a guide/reference and to assist in policy development	2

The frequency of guideline use varies considerably. The general frequency of guideline use is summarized below.

Table 9. Frequency of Use of the Guidelines

Frequency	Few Times a Year	Monthly	Weekly	At least Daily	Variable	Not Specified
Number of Respondents	2	4	2	7	7	6

Some respondents use the guidelines constantly in their work (*i.e.*, hourly) and others use the guidelines very infrequently (*i.e.*, a couple of times per year). One third (32%) of the respondents, indicated that they refer to the guideline at least daily. The same number of respondents, indicated that frequency of guideline use is variable (not constant from day-to-day). Two respondents indicated that they only refer to the guideline a couple of times per year. Six participants did not specify how frequently they use the guidelines.

Question A4. Throughout the course of your career have you had to take action (*i.e.*, issue a water usage advisory) due to the presence of a contaminant (physical, chemical, radiological, and/or microbial) in drinking water at concentrations exceeding water quality guideline values? What did this action entail?

Twenty-six out of 28 participants have taken action based on an exceedance of a guideline value. The two respondents who indicated that they had not taken action do not consider themselves as being in a position to do so (*i.e.*, technical advisory role). Each participant who has taken action has done so due to microbiological exceedances of the guideline value. Action has also been taken based on exceedances of antimony (MAC), arsenic (MAC), fluoride (MAC), iron (AO), lead (MAC), manganese (AO), nitrates (MAC), sodium (AO), sulphate (AO), uranium (MAC), selenium (MAC), THMs (MAC), turbidity, hardness (no numerical guideline) and microcystin (MAC). It is important to observe that most action has been taken based on a handful of exceedances of either MACs or AOs.

The public health professionals interviewed have an appreciable amount of training and knowledge, based on education and work experience. It will be assumed that this observation may be applied to cover the broad population of public health professionals throughout Canada. Although the level of practical hands-on experience will vary, public health professionals are consistently trained through standardized educational programs to qualify for certification by the Canadian Institute of Public Health Inspectors. However, given the diverse nature of the issues they are trained to recognize (*i.e.*, food safety, disease surveillance, air quality, *etc.*), evaluate and control, it is recognized that only a relatively small portion of formal training and work experience is directly related to drinking water.

General knowledge of broad public health issues seems appropriate. However, knowledge pertaining to specific drinking water issues is limited for some respondents. This was typically observed in interviews with professionals from smaller health regions where public health professionals are responsible for a broad spectrum of public health issues. Based on interview responses and general discussions, there appears to be some value in designating experienced public health professionals as "drinking water specialists" so they can focus primarily on public health risks related to drinking water. Because of limited resources, this can be a challenge for smaller RHAs. Therefore, one respondent suggested appointing provincial drinking water specialists that public health officers may use as a resource. The assistance of larger RHAs in providing technical support on drinking water issues was acknowledged and is appreciated.

The use and application of the GCDWQ is fairly broad and they are not used exclusively as a comparison tool for water quality results. The GCDWQ are commonly adopted into regulatory structures, policies and guidance documents developed for the drinking water industry and regulators. As discussed in Section 2.1.4., five provinces/territories have specifically incorporated the GCDWQ into provincial legislation. It is important to note that the GCDWQ are also incorporated into regulatory schemes for other applications like environmental regulations. For example, the GCDWQ are used for environmental remediation as the default or (Tier 1) remedial goal for groundwater at contaminated sites in many provinces.

It is important to note that many respondents indicated that it can be difficult to follow the risk assessment process documented within the technical documents. Based on the results of the interviews, there is a general perception that the risk assessments used to derive the GCDWQ lack transparency. This is an important finding considering "a health risk assessment conducted behind closed doors, without open access to the information upon which its conclusions are based, can not be defended and will generally lead to more questions than answers" (Government of Western Australia, 2006).

4.2.2 Section B: Guideline Development Knowledge

The questions within Section B were aimed at evaluating the interviewee's level of knowledge and understanding pertaining to the guideline development process used by Health Canada. Section B responses are summarized in Appendix E, Tables E5 through E11.

Question B1. How knowledgeable are you with the process used to establish the *Guidelines for Canadian Drinking Water Quality*? How would you rate your knowledge? (1-do not know what the process is to 5-know and understand the process extremely well).

A numerical response to this question was provided by 26 of the 28 interviewees. Of the two respondents who did not provide a numerical response, one indicated that they had knowledge of the process used to develop the microbial guideline values only and the other indicated that they were very knowledgeable with the process in general. The remaining 26 respondents rated their knowledge between one, do not know what the process is and five, know and understand the process extremely well. The responses are summarized and evaluated below.

Based on the results, the respondents generally feel that they have an average level of understanding of the process used by Health Canada to derive the numerical guideline values. However, of those who provided a numerical response, almost 20% indicated that they have no knowledge of the guideline development process.

Figure 6. Guideline Development Knowledge

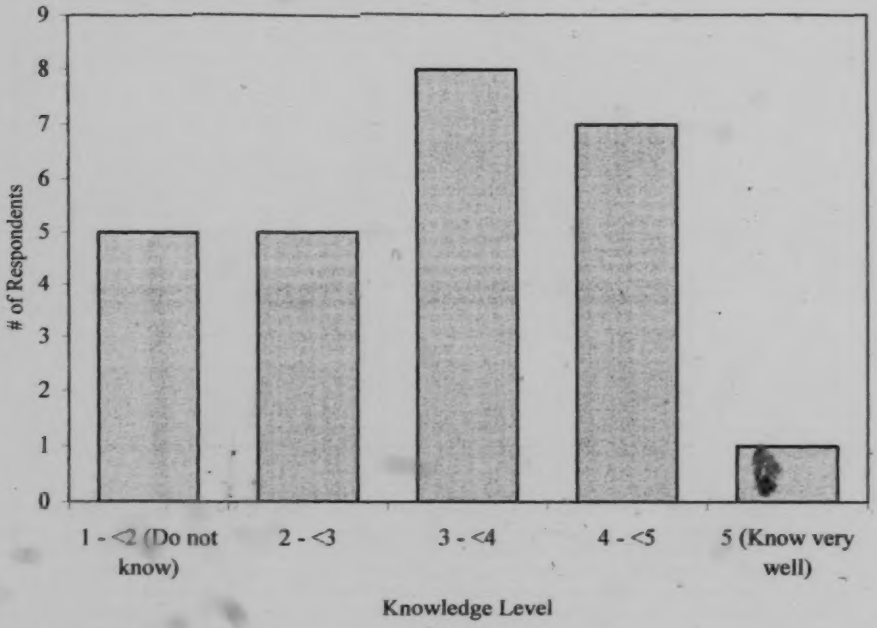


Table 10. Guideline Development Knowledge – Data Evaluation

Parameter	Value
Number of Numerical Responses	26
Minimum	1
Maximum	5
Mean	2.85
Median	3
Mode	3

If the responses are indicative of the level of knowledge throughout the broader population of public health professionals, it is disconcerting that 20% of public health professionals claim to have no knowledge of the guideline development process. In consideration of the magnitude of the risk management decisions being made based on the guideline values and the economic and public health implications of these decisions, or lack of decisions, sound knowledge of the derivation process should be considered an essential requirement for public health professionals responsible for managing risks from drinking water. Candid discussions with respondents indicate that "their plate is full" managing a wide range of public health issues and they do not have time to become familiar with the guideline value derivation process used by Health Canada. Accordingly, in these situations it is assumed that the guideline value is appropriately developed and based on acceptable scientific practices.

Question B2. Are you familiar with the supporting technical documents created by Health Canada for established guideline values? How would you rate your familiarity with the supporting technical documents? (1-never heard of them to 5-know and understand the contents very well)

Of the 28 individuals interviewed, 16 provided a numerical value to rate their familiarity with the supporting guideline technical documents created by Health Canada. The 16 respondents rated their familiarity between one, have never heard of the documents and five know and understand the contents very well. The responses are summarized and evaluated below. Ten respondents indicated that their familiarity with supporting technical documents varied considerably depending on the specific parameter. Responses are summarized below.

Figure 7. Familiarity With Supporting Technical Documents

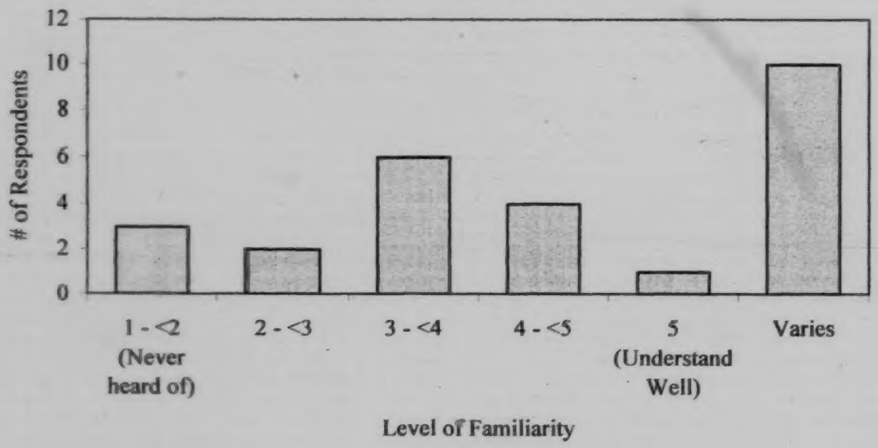


Table 11. Supporting Technical Document Familiarity – Data Evaluation

Parameter	Value
Number of Numerical Responses	16
Minimum	1
Maximum	5
Mean	3.03
Median	3
Mode	3

Based on the results summarized above and a median response value of three, the respondents generally feel that they have a moderate level of familiarity with the supporting technical documents developed by Health Canada. Clearly, familiarity of supporting technical documents is higher for those parameters for which respondents have experience. Guideline technical documents for turbidity and microbiological parameters were commonly listed as those that respondents are most familiar with. Respondents indicated that they generally do not become familiar with the contents of a technical document until they are faced with a drinking water issue that requires their response or management.

Question B3. For the practical application of guideline values, how useful are the supporting technical documents or any other documents published by Health Canada (list any identified)? (1-Not useful, could do without 5- extremely useful).

Twenty interviewees provided a numerical response to this question. The usefulness of the supporting technical documents was rated between one, not useful and could do without, and five, extremely useful. For those who use the supporting technical documents, the majority of the respondents indicated that the documents are useful. Respondents generally felt that the supporting technical documents are a good resource that provides important background information to assist in the evaluation of risk and they help to explain how the numbers are derived. It is positive to note that only two out of 20 respondents rated the usefulness of the supporting technical documents less than three. However, some respondents did indicate that there are some frustration points with the documents that lead to confusion and/or fail to provide required answers.

Five respondents indicated that they do not rely on the technical documents exclusively and they look to other sources of information (*i.e.*, WHO, US EPA, *etc*.). It was also noted that the supporting documents are not useful if they are not up to date or do not include the latest technology. In summary, the respondents indicated that the supporting technical documents are reasonable and useful but there is room for improvement. Responses are summarized below.

Figure 8. Supporting Technical Document Usefulness

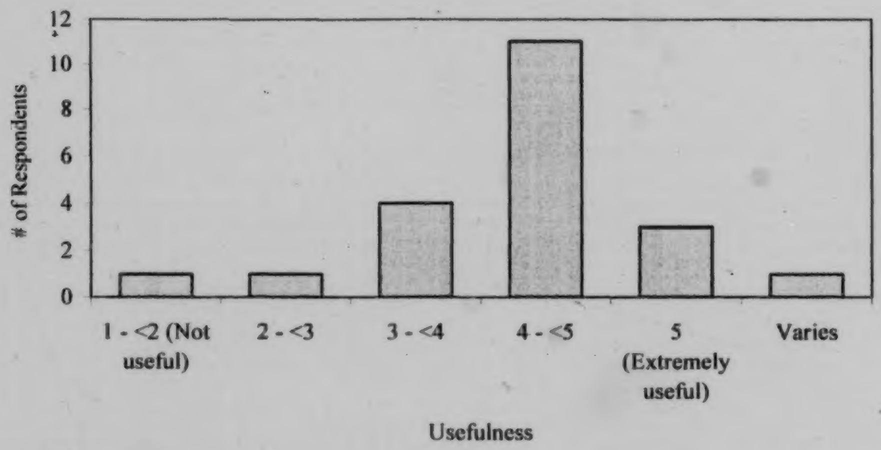


Table 12. Supporting Technical Document Usefulness – Data Evaluation

Parameter	Value
Number of Numerical Responses	20
Minimum	1
Maximum	5
Mean	3.78
Median	4
Mode	4

Based on the results summarized above and a median response value of four, the respondents generally feel that supporting technical documents or any other documents published by Health Canada are useful for their specific application.

Question B4. What are the major sources of uncertainty in numerical guideline values for chemicals in drinking water?

There is a large amount of uncertainty inherent in environmental health risk assessment. This question was asked to evaluate if respondents were familiar with major sources of uncertainty in health risk assessment used to derive numerical guideline values. All 28 participants responded to this question. Of the 28 who responded, two individuals indicted that they had no idea what the major sources of uncertainty were. Five other respondents indicated that they were not familiar with the concept but provided their best guess. Two respondents recognized that there are large amounts of uncertainty but did not specify sources of uncertainty. For the 24 respondents who provided specific sources of uncertainty, the results are summarized as follows:

Table 13. Major Sources of Uncertainty in Numerical Guideline Values

Major Source of Uncertainty	Number of Respondents who Listed Source of Uncertainty
Measurement Error (Human, Equipment or Methodology)	2
Uncertain Exposure Factors	13
Intra-species Variation	3
Lack of Data	8
Animal to Human Data Extrapolation	13
Quality of Available Scientific Information/Evidence	9
Uncertain Toxicological Parameters	2
Politics, risk management, perceptions and interpretations	5

According to those who responded, uncertainty associated with exposure assessment and the extrapolation of animal data to humans are the major sources of uncertainty most frequently listed. Over half of the respondents who provided answers listed these as major sources of uncertainty. The quality of available scientific information and the lack of available data were provided as major sources of uncertainty by nine and eight respondents, respectively.

In summary, it was generally acknowledged by the respondents that there is a large amount of scientific uncertainty and variability associated with using numerical risk assessment in the development of environmental health guideline values. However, the relative contribution of each element of uncertainty to the overall uncertainty does not appear to be well understood. The responses indicate that uncertainty primarily results from insufficient epidemiological evidence. Several respondents highlighted that exposure assumptions, including average body weight, average life span, daily rate of intake of drinking water, and allocation factor may not be representative of real exposure scenarios and were provided as sources of uncertainty by 13 respondents.

Assumptions related to toxicological parameters resulting from the use of non-human laboratory studies were listed as sources of uncertainty by only two respondents. The basis for the derivation of the NOAEL or the LOAEL, including the selection of the most appropriate study, the methodology or model used to describe cancer potency, and uncertainty factors applied to the derivation of an acceptable daily intake or reference dose were not specifically listed as significant sources of uncertainty. It is important to note that overall, these are significant sources of uncertainty but they do not appear to be recognized as such by the respondents.

Although the need to extrapolate across species to humans was listed as a source of uncertainty by half of those who provided responses, sources of uncertainty within the specific animal studies (*i.e.*, shorter exposure period, different exposure vehicle; testing limited to adult animals, relatively high doses of chemicals, small numbers of test animals, *etc.*) were only specifically listed as sources of uncertainty by one respondent.

Five respondents indicated that interpretations and judgments made during the risk management component of guideline development are major sources of uncertainty. The responses indicate that this uncertainty is partially a result of a failure to clearly explain adjustments made to the numerical guideline value based on government policies and the risk management decisions made by individuals that are influenced by values and personal opinions.

Question B5. How is uncertainty pertaining to expected health effects addressed in the *Guidelines for Canadian Drinking Water Quality*?

Of the 28 individuals interviewed, 27 provided responses to this question. Seven respondents do not know how uncertainty is addressed in the guidelines. Four respondents felt that uncertainty was addressed by being conservative and using the worst case scenario or an upper-bound estimate of the risk when establishing the guideline value. Ten respondents listed uncertainty or safety factors as a means of accounting for uncertainty in the guideline. Three respondents indicated that although they knew uncertainty was considered, the documents are not clear in explaining how uncertainty is taken into account. Two respondents indicated that although uncertainty is discussed in the guideline documents, it is primarily taken into account during the application of the guidelines by using best judgment and common sense. This is done subjectively and somewhat arbitrarily based on individual circumstances, knowledge and beliefs. One respondent indicated that uncertainty was accounted for through the use of standardized assumptions used in the risk calculation. However, in reality the use of standardized assumptions (*i.e.,* default toxicological and exposure parameters) only introduces more uncertainty and variability and does nothing to address uncertainty. In summary, based on the responses, the majority of respondents are not familiar with how specific sources of uncertainty pertaining to expected health effects are addressed in the guidelines.

Public health professionals are faced with the difficult task of designing and implementing environmental and health initiatives which produce the most benefit for the most people. Failure to adequately characterize and quantify uncertainty makes it difficult for public health professionals to make the most appropriate decisions with available information when faced with a number of risk management options. A thorough analysis of the sources of uncertainty can assist public health professionals with putting things into perspective and avoid over-reliance on numerical guideline values. There appears to be a lack of understanding regarding how uncertainty is addressed in the guideline numbers. This lack of understanding will inevitably result in the application of numerical guideline values in a manner for which they are not intended. This is demonstrated when numerical guideline values are applied as hard and fast rules when managing slight exceedances of select chemicals in drinking water.

The responses are not indicative of a solid understanding of sources of uncertainty and how they are addressed in the GCDWQ. As discussed in Section 2.2, uncertainty may arise for several reasons and it needs to be addressed at each step of the risk assessment process. Further, an overall assessment of uncertainties is essential for planning future studies or monitoring strategies intended to fill gaps in current knowledge and potentially reduce levels of uncertainty (Government of Western Australia, 2006). Using the benzene and THM technical guidance documents as an example, sources of uncertainty are not specifically called out and discussed in one section, they are hidden throughout the document. If all the uncertainty is not evaluated holistically and discussed, we miss out on potential opportunities to develop appropriate strategies for reducing uncertainty.

Question B6. The following are examples of uncertainty factors (UFs) that have been used in Health Canada risk assessments to derive numerical guidelines: Lead: UF < 2; TCE: UF = 100; Antimony: UF = 300; and THM (based on chloroform): UF = 2,100. What do these UFs tell us about the corresponding guideline values?

The determination of the TDI, used to derive the guideline value for a non-carcinogen requires the application of an uncertainty factor (UF). Generally, a factor of one to 10 times may be used to account for each of the following elements of uncertainty: intraspecies variation, interspecies variation, nature and severity of effect, adequacy of study and LOAEL versus NOAEL. An additional factor of one to five times may be incorporated where there is information that indicates a potential for interaction with other chemicals. If the chemical is an essential nutrient at low concentrations, the dietary requirement may also be taken into consideration when determining the UF. The concept of applying uncertainty factors is an important aspect of risk assessment for non-carcinogenic and non-genotoxic carcinogens. In general terms, a lower UF can be interpreted as having greater confidence in the numerical guideline value. This question was posed to evaluate if users of the guideline values are familiar with UFs and what they tell us about scientific knowledge and confidence in the resulting guideline value.

In total, 27 participants provided a response to this question. In general, the majority of participants who answered the question seem to have a basic understanding of what UFs are and what they tell us about the corresponding guideline value. Four respondents indicated that they did not know what UFs are. In fact, one respondent indicated that they had never heard the term "uncertainty factor" prior to the interview.

The respondents indicated that a relatively large UF generally means less certainty and more specifically:

- More examination of the scientific literature and evidence is required for the given parameter
- More interpretation of the guideline value is required before it is applied
- Little confidence in the guideline value
- A more thorough review of the technical documents may be required
- More difficulty in communicating the potential health risks associated with an exceedance
- Less is known about the health effects relative to those with low uncertainty factors
- There is a large amount of uncertainty and extrapolation involved in the derivation of the guideline
- There is less certainty that there will be a health effect from exposure at the guideline value
- The corresponding guideline value is more protective/conservative than those with lower uncertainty factors
- There is not a lot of information upon which to base a number so a best estimate/guess is used

The respondents indicated that risk management decisions made using guideline values with high uncertainty factors can be a "headache" for regulators as it is much more difficult to articulate possible health outcomes and ultimately make a decision based on the application of the guideline value. As follow-up, select respondents were asked if they felt there should be a cut-off point where a MAC would not be derived if the uncertainty factor were too high. Only a few respondents felt that a MAC should not be derived when UFs remain too high. What would be considered too high was not discussed.

However, the important insight gained from this question is that several respondents generally felt that they have to fulfill a mandate based on precautionary principles and that the specific margin of safety, although it needs to be considered, does not necessarily make a difference in the application of the guideline. Rather, the UFs should be used as an action and communication point to assist during the risk management process. UFs and the process used to derive them should be communicated when guideline values are applied.

The tabular summary presentation of the guideline values does not indicate the varying levels of uncertainty contained within each of the guideline values. For example, lead and THM guideline values are presented the same and by only looking at the tables, one would assume that we have comparable levels of knowledge regarding the expected health effects. For many of the respondents this is misleading. As further discussed in the response section to question C4, one of the things that should be considered in the prioritization of guideline values is the amount of certainty in the guideline value and likelihood of possible health outcomes.

Question B7. According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a carcinogen in drinking water may cause cancer in humans: a) zero; b) at the guideline value; c) unknown exactly, but expected to be at a concentration significantly higher than the guideline value; d) any concentration; or e) do not know?

Twenty-four interviewees provided an answer to this question. The responses are summarized in the following table.

Table 14. Question B7 Summary of Responses

Response	Number of Responses
a) zero	0
b) at the guideline value	1
c) unknown exactly, but expected to be at a concentration significantly higher that the guideline value	10
d) any concentration	6
e) do not know	7

The *Approach to the Derivation of Drinking Water Guidelines* published by Health Canada states "it is assumed that there is a probability of harm at any level of exposure to carcinogenic chemicals" (Health Canada, 1995). Based on this, the most appropriate answer was anticipated to be d) any concentration. Only 25% of the respondents selected this as their response. Almost 30% of the respondents did not know and the majority of respondents selected "c" as their answer.

Health Canada estimates human health risks at low exposure levels to carcinogens using linear, zero threshold dose-response models with very conservative assumptions. As a result of the conservative assumptions most respondents may interpret this to mean that the resulting guideline value is established well below a level which it is anticipated that any adverse health effect will occur. However, because the model is linear at low doses and assumes no threshold, it is inherently assumed that there is no level of exposure to a carcinogen where the cancer risk is zero. Therefore, the guideline value is established assuming that exposure to a carcinogen causes cancer at any concentration, based on an acceptable level of incremental lifetime risk.

Question B8. According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a non-carcinogen in drinking water may cause an adverse health effect in humans: a) zero; b) at the guideline value; c) unknown exactly, but expected to be at a concentration significantly higher than the guideline value; d) any concentration; or e) do not know?

Twenty-three individuals provided an answer to this question. The responses are summarized in the following table.

Table 15. Question B8 Summary of Responses

Response	Number of Responses
a) zero	0
b) at the guideline value	2
c) unknown exactly, but expected to be at a concentration significantly higher that the guideline value	14
d) any concentration	0
e) do not know	7

Health Canada's TDI approach used to develop the guidelines for non-carcinogens ensure that the established MACs are far below (*i.e.,* 10 to 10,000 times) exposure levels at which any adverse health effects have been observed (Health Canada, 1995). The most appropriate answer was anticipated to be c) unknown exactly, but expected to be at a concentration significantly higher that the guideline value. 61% of the respondents selected this as their response while 30% of the respondents did not know and the remaining respondents selected "b" as their answer.

When presented with the two interview questions above, a representative from Health Canada indicated that it is difficult to neatly classify the responses according to the options presented. It was stressed that although Health Canada follows a general methodology for risk assessment of carcinogens and non-carcinogens, there is no simple formula during the risk assessment of any group of chemicals. Each chemical is separately examined based on its physical and chemical properties, its potential [illegible] cause harm, its toxicity, and the various routes of exposure. With that stated, the responses provided by Health Canada for questions B7 and B8 are summarized below.

In general, for carcinogens the answer depends on the mode of action of the carcinogen. Although not explained in available guidance documents (Health Canada, 1995 and 1999), according to Health Canada methodology, a carcinogen with a genotoxic mode of action may theoretically cause cancer "at any concentration". However, managing to a zero health risk is not necessarily feasible for numerous reasons. Therefore, according to Health Canada representatives, guidelines are established such that the increased risk for cancer as a result of exposure to the chemical would be considered negligible. For carcinogens that are not known to have a genotoxic mode of action, the approach assumes that there is a threshold below which no cancer is observed and an adverse health effect is "expected to be at a concentration significantly higher than the guideline value."

For most of the chemicals in drinking water, according to Health Canada risk assessment methodology, an adverse health effect is "expected to be at a concentration significantly higher than the guideline value." As for non-genotoxic or epigenetic carcinogens, it is assumed that there is a threshold below which no adverse health effects are observed. Health Canada considers specific uncertainty and exposure factors such that a 'margin of safety' exists around the established guideline. However, at times, according to a Health

Canada representative, the established guideline values may be closer to the adverse effect depending on the hazard and/or toxicity information and other factors.

The analysis of the responses to the two questions above, and in consideration of the responses provided by Health Canada, demonstrates that there is a significant amount of confusion surrounding carcinogenic and non-carcinogenic risk assessment. Based on the responses and discussions surrounding the questions, respondents do not seem to understand the differences in the processes used to derive numerical guideline values for carcinogens *vs.* non-carcinogens and the relevance of mode of action for carcinogens. The *Approach to the Derivation of Drinking Water Guidelines* provides details regarding risk assessment methods employed by Health Canada to derive numerical guideline values for drinking water quality (Health Canada, 1999). However, this document provides no distinction between genotoxic and epigenetic carcinogens. Regardless, it is not anticipated that making this distinction would change the level of understanding the respondents have of genotoxic carcinogenic risk assessment and non-genotoxic carcinogenic risk assessment.

4.2.3 Section C: Risk Management

The general objective of the following questions was to evaluate the effectiveness of risk management decision making resulting from the application of the guideline values, as currently presented. Section C responses are summarized in Appendix E, Tables E12 through E26.

Question C1. How would you define "safe drinking water"?

The question was posed to attempt to understand the interviewee's concept of safety as it pertains to drinking water. When asked, the question was considered to be quite difficult by most interviewees. A wide variety of responses were provided to this question. Some respondents referred to definitions already developed by the WHO and the Walkerton Inquiry to define safe drinking water and or the definition of potable water provided within their provincial regulations. However, these definitions could only be articulated during the interview by a few respondents. The majority of respondents indicated that meeting objectives for microbiological standards and/or being free of microbial contamination is the most important element for assuring safe drinking water.

However, most recognize that the definition of safe water is much more than meeting water quality guidelines and there are many uncertainties and grey areas. The general themes identified through the interviews are summarized below.

- Consistent with the WHO (2004) definition of safe water, water is considered safe if you can drink it over a lifetime or throughout all life stages and it doesn't add to your health risk or burden, will not cause an unacceptable risk of waterborne illness (from microbial or chemical hazards), and/or will not cause people to get sick.
- Safe water can only be produced if there is a multi-barrier approach applied (*i.e.*, source water protection, competent operators, adequate system maintenance, backflow protection, no complaints from consumers, restricted access, *etc.*) and there is regulatory oversight.
- One element of safe drinking water is monitoring to ensure the water meets the GCDWQ, or the intent of the guidelines, as drinking water could still be "safe" if there is an exceedance of a guideline value. However, it was also recognized by several respondents that water could also be "unsafe" even if routine monitoring objectives are met.
- There needs to be consideration for consistency in the definition of safe water.
- The safety of water will always be limited by current science and technology.

Ultimately, it is difficult to define safe drinking water. Increasing knowledge makes drinking water safety a complicated issue. The biggest challenge in defining safe drinking water lies in the defining the word "safe". Safe means different things to different people. Some respondents referred to absolute safety or zero risk concepts that would be impossible to achieve (*i.e.*, "safe drinking water must be free from the risk of contamination"). In summary, there is no broadly endorsed standard definition of safe drinking water used by public health professionals. However, if the goal of the drinking water guideline values is to produce safe, reliable drinking water, defining safe drinking water, or at least creating a common working concept, is important. The determination of a generally accepted definition of safe drinking water may also help public health professionals avoid mistakenly using misleading zero risk concepts when explaining safe drinking water.

Question C2. Traditionally, drinking water suppliers and regulators have relied heavily on compliance monitoring to ensure the safety of drinking water. What are the practical and conceptual limitations of compliance monitoring for assuring safe drinking water?

This objective of this question was to evaluate the respondents understanding of the limitations of sampling and monitoring, including potential for errors (*i.e.*, human, analytical), inherent limitations (will only identify what you are analyzing for) and variability (*i.e.*, sample preservation, sampling procedures, analytical methods, inherent characteristics of treatment system, *etc*.).

All 28 interviewees provided a response to this question. The most common limitations of compliance monitoring are: 1) it is a snapshot in time; 2) it only represents a very small portion of water in the distribution system; and 3) it is reactive/after-the-fact. The main practical and conceptual limitations of compliance monitoring provided by the respondents include, but are not limited to the following four points:

- Collecting representative samples is a challenge (*i.e.*, sample location, sampling method, qualifications of person collecting the sample, *etc*.) due to the heterogeneous distribution of contaminants within a system and sampling frequency and methodology (*i.e.*, sample every Monday from the same point in the system).
- The overall sampling plan is typically based on assumptions that may not be correct. This can result in misleading monitoring programs that are exclusive in that they may fail to include the monitoring of select, critical parameters or only address bacteriological parameters.
- Sample collection and laboratory methods and analysis are susceptible to human and equipment errors.
- Sample collection, transport and analysis are limited by financial (*i.e.*, expensive) and logistical (*i.e.*, getting the sample to the lab within the specified time frame) considerations.

In general, the majority of respondents identified several common conceptual and practical limitations of compliance monitoring. Ultimately, compliance monitoring only provides specific, limited and reactive information about the quality of a small amount of water within a distribution system and sampling results are not predictive of population health risk. Further, monitoring programs will always be limited by current science and technology.

Question C3. Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion? How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs.* chemical parameters?

The above question was aimed at evaluating the respondents understanding of the relative contribution of guideline values for microbial *vs.* chemical parameters to reducing public health risks.

Twenty-five out of the 28 interviewees were specifically asked this question. Twenty-four of the interviewees believed that microbial-related illness occurred more often from drinking water than chemical-related illness. In general, this belief is based on professional opinions, personal experience, personal knowledge, general knowledge of the drinking water industry, observations made in the field, enteric and communicable disease reports, and confirmed occurrences of water-borne illness (*i.e.*, Walkerton, North Battleford, others). It is also believed that water systems are more commonly contaminated by microbial agents versus chemicals, resulting in more exposure and therefore, more microbial-related illness relative to chemical-related illness. Further, chemical contamination events are typically spills or accidental releases. The public is usually made aware of these types of incidents and the water typically has an unpleasant odour or taste so consumption is limited and potential exposure is minimal. One interviewee did not know which occurred more because conclusive data does not exist.

Various difficulties with making associations between exposure to chemicals in drinking water and illness were discussed. These difficulties include the chronic nature of the expected adverse health outcomes, prevalence of cancer in the general population, uncertainties with exposure assessment and the lack of chemical water quality data. Because of these inherent difficulties, there is no way to know for sure which chronic health outcomes/illnesses can be attributed to exposure to chemicals in drinking water.

As a result, information pertaining to illness resulting from exposure to chemicals in drinking water is generally not available. This does not necessarily mean that adverse health outcomes from exposure to chemicals in drinking water are not occurring; the practical means to confirm or validate a suspected causal relationship are not available.

The interviewees indicated that day to day, in the practical sense there is greater emphasis placed on microbiological parameters in drinking water. This is evident through more frequent sampling and analysis for microbial parameters, more urgency surrounding microbial issues, more vigilance around the evaluation of microbial testing results, and more frequent action (*i.e.*, notifications and boil water advisories) taken due to microbial contamination events relative to chemical events. However, with a few exceptions, the respondents generally believed that the relative importance of microbial parameters was not reflected in the GCDWQ. Specifically, the chemical section is much larger and more complex. Although it is recognized that there are sections within the GCDWQ that state that microbial risks are much greater than chemical risks, seven respondents explicitly suggested that there be more emphasis on microbial parameters, relative to chemical parameters in the presentation of the GCDWQ. Four respondents believed that in the eyes of the public, chemical parameters are given a higher priority because they are not well understood relative to microbial parameters.

These findings are significant because increasing resources are being allocated to managing potential risks that may result from exposure to chemicals in drinking water. As a result of the increase in allocated resources and misguided media attention, public concern is increasingly focused on chemical contaminants, shifting the focus away from the demonstrated risks to public health from exposure to microbial contaminated drinking water.

Question C4. Health Canada has developed numerical, health-based, drinking water quality guideline values for numerous (approximately 64) chemical parameters. Do you think that each of these chemical parameters all warrant the same level of attention? If yes, why? If no, what should the level of attention depend on? Do you think that the *Guidelines for Canadian Drinking Water Quality* are presented in a way that adequately reflects the relative levels of attention that are warranted?

This question was asked to evaluate if the respondent believes that all chemical contaminants should be treated equally. Twenty-seven interviewees were specifically asked the above question. Twenty-five respondents indicated that they do not think that each of the chemical parameters warrants the same level of attention. One respondent indicated that they did not deal with the chemical parameters regularly enough and therefore, didn't know and one respondent indicated that all chemical parameters warrant the same level of attention. For those respondents who think that different levels of attention are warranted, they indicated that the level of attention should depend on the following:

- Potential health effects of the parameter
- Frequency or likelihood of occurrence in drinking water system
- Level and type of exposure
- The population at risk (*i.e.*, children, adults, pregnant women)
- Concentration of the chemical in drinking water and extent of exceedance
- The amount of science and certainty supporting the established guideline value
- Characteristics of the water supply and surrounding environment

Ultimately, based on the responses, the relative level of attention given to chemical parameters should be determined through a site or system-specific risk assessment and prioritization process.

The majority of respondents (16 out of 25) do not think that the GCDWQ are presented in a way that adequately reflects the relative levels of attention different chemical parameters warrant. The respondents indicated that the guidelines are essentially all grouped together and presented equally without any established hierarchy. A couple of respondents indicted that through the use of AOs and MACs, the relative attention that is warranted is implied. Two other respondents felt that prioritizing the parameters is not the role of the guidelines and individual public health professionals should determine the level of attention that may be warranted based on specific, local conditions. However, based on general discussions throughout the interviews the majority of respondents felt that there could be some changes to the presentation of the GCDWQ and some direction given with respect to the relative prioritization of individual parameters.

Question C5. For how many of the parameters included in the *Guidelines for Canadian Drinking Water Quality*, do you think there is established evidence of causing human health impacts via drinking water exposure?

The objective of the above question was to identify the number of chemicals that respondents believe have established evidence of causing human health impacts via drinking water. Twenty-six interviewees were specifically asked the above question. The responses were grouped into four categories and are summarized in the following table:

Table 16. Question C5 Summary of Responses

Response	Number of Responses
Very few/less than half	10
Most or all/more than half	9
Do not know	5
It depends	2

Of the 19 respondents who offered a direct opinion, the responses are nearly split. As indicated in the above table, 10 of the respondents think that there is established evidence of causing human health impacts via drinking water exposure for very few, or at least less than half of the parameters, and nine of the respondents think that there is established evidence for most or all of the parameters included in the GCDWQ. Two respondents did not directly answer the question. One respondent indicated that the response largely depends on how "established evidence" is defined and the other stressed the amount of uncertainty, particularly with the extrapolation of health risks to the human population. Five respondents did not know.

Lead was most commonly (11 respondents) provided as an example of a chemical that has established evidence of causing human health impacts via drinking water exposure. Other examples were varied but most commonly included: arsenic (five times), fluoride (four times) and nitrate (three times). THMs, copper, benzene, toluene, ethylbenzene and xylenes, pesticides and herbicides, sulphates, and mercury were other examples provided by the respondents. There were two key elements to this question: 1) "established evidence" and 2) "via drinking water exposure". Of these parameters, the numerical values for copper and sulphate in the GCDWQ are based on aesthetic considerations. There is no established evidence of causing human health impacts via drinking water exposure for either copper or sulphate. Although, at high doses (greater than 15 mg/day) copper may be toxic, the AO has been established well below this level (Health Canada, 1992). The AO for sulphate is based on taste considerations (Health Canada, 1987b). For the remaining parameters, excluding THMs, although evidence of causing human health impacts has been established, there is no evidence that links the health effects to exposure via drinking water. With respect to THMs, there is a lack of conclusive evidence pertaining to expected health effects (SENES Consultants Ltd., 2003).

For some public health professionals, there is an apparent misconception or assumption that because there is an established guideline value there is established evidence of causing human health impacts via drinking water exposure. The GCDWQ list 66 parameters for which numerical, health-based guideline values have been established (Health Canada, 2007a). Similarly, almost 200 chemicals are included or have been considered for inclusion in the WHO guidelines (WHO, 2004). Understandably, given the long list of substances, prioritizing competing risks to safe drinking water based on established evidence is a growing struggle (Rizak and Hrudey, 2007b). The most significant risks to people's health from drinking water are posed by microbiological organisms such as disease-causing bacteria, protozoa and viruses (WHO, 2007). The WHO has identified a limited number of chemicals that present serious health hazards due to exposure via drinking water. These include: fluoride, arsenic, selenium, nitrate, iron, manganese and lead (WHO, 2007). Locally, illness resulting from exposure to arsenic in drinking water has been reported in British Columbia (Copes, 2006).

Although it is possible that risks from select chemicals in drinking water may emerge as significant public health issues, more rigorous grounds for identifying such risks are required. The Canadian Water Network (CWN) stresses that improved understanding and communication of the evidence and uncertainty for risks of trace contaminants is needed to provide a basis for improved decisions given the inevitable risk tradeoffs arising when allocating limited resources (CWN, 2007). Risk management decision makers and regulators need to understand how achieving numerous chemical guideline values contributes to reducing overall public health risks relative to other (*i.e.*, microbial) guideline values.

Drinking water providers and regulators need to maintain a primary focus on effective treatment processes known to manage proven health risks, while keeping a precautionary research perspective on potentially important risks from trace contaminants (CWN, 2007). There also needs to be consideration given to any characteristic that has the potential to make drinking water unpalatable without necessarily posing a health hazard (Hrudey and Hrudey, 2004). Drinking water that is not palatable will drive consumers to look to alternate, possibly less-safe sources of drinking water.

Individual chemicals included on the long lists of substances for which numerical guideline values are developed are only likely to pose a safety concern in specific local circumstances. This reality must be clearly understood among drinking water providers, the regulators and public health professionals and the consumers. For the most part, chemicals in drinking water do not warrant the same level of attention as the priority chemicals or pathogens, unless there is specific evidence that they do pose a local problem (Rizak and Hrudey, 2007b). As such, chemical guideline values warrant varying levels of attention depending on specific local conditions.

In summary, not all chemical parameters included in the GCDWQ have established evidence of causing human health impacts via drinking water exposure. However, some experienced public health professionals believe that once a guideline value is published, it must be assumed that there is established evidence of causing human health impacts via drinking water exposure because irrespective of whether there is established evidence of causing human health impacts via drinking water exposure or not, if there is a published guideline value it must be applied because it demonstrates due diligence. This is demonstrated in the following quotations from the interview responses:

> "I am not allowed to ignore [a guideline value] because that's due diligence. So that's the reality of when they create a guideline, if they're going to create a guideline, it's got to be applied."

> "It's a challenge…but if they're going to set them and call them health guidelines, you know, I'm just an inspector. I just have to say okay, I've got to apply this. I have to assume [they] know what they're talking about."

Along the same lines, when asked how much could a chemical concentration exceed a guideline before you would expect to see the adverse health effects in the consuming population? Some respondents indicated that it is not up to them to decide.

> "As a public health person it doesn't really matter when I would expect to see them. The idea is to protect the public. We just take the precautionary approach. It's not up to me to decide. We'll give the information to the public and then they can make an informed decision about what's important to them with respect to acceptable and unacceptable risks. So I think the priority for me is getting the information for water quality to the public along with the information that they need."

> "Generally above the guidelines, it is no good no matter what the risk is and we will try to remediate that situation - we are looking at lifetime consumption so we have some time to deal with that situation."

In consideration of the above responses, due diligence is an important consideration in the evaluation of the role and effectiveness of the GCDWQ. Under certain circumstances could a public health professional be diligent without strict application of a numerical guideline value? Applied to public health, due diligence means that health agencies shall take all reasonable precautions, under the particular circumstances, to prevent injuries or illness to the public. This duty also applies to situations that are not addressed elsewhere in public health legislation. To exercise due diligence, the health agency, municipality and/or water utility must implement a plan to identify foreseeable risks and carry out the appropriate mitigative action to prevent illness from these health hazards (adapted from: Canadian Center for Occupational Health and Safety [CCOHS], 2008).

Taking all reasonable care under the given circumstances to protect the health of the public from risks associated with consuming the drinking water in question would be considered due diligence. Keeping in mind that what may constitute due diligence in one situation may be totally inadequate in the next situation. The goal is to foresee risks and protect the public from them.

Question C6. When a water use advisory is issued as a result of a chemical in drinking water at concentrations exceeding the guideline value, secondary risks may be posed. Of the following secondary risks, which ones do you think have the potential to significantly impact public health? inadequate personal hygiene (not bathing, not washing hands), inability to cook nutritious meals, reduced water intake, stress/fear and decreased confidence in water supply, re-allocation of limited personal economic resources to purchase alternative, more expensive sources of water, not washing produce (fruit/vegetables) prior to eating, and not cleaning home/office, personal injury (*i.e.*, scalding). Rate the significance on a scale of 1-5 (1 = no significance to 5 = very significant). In your opinion, are there any other secondary risks to consider?

This question was aimed at evaluating how the respondents would rate the significance of any possible secondary risks that may be introduced when a water use advisory is issued. Only 15 of the interviewees were specifically asked this question. For the remaining 13 interviews, there was either not enough time to present the question or based on the general discussion throughout the interview in consideration with the interviewee's current position, it was not felt that a response to the question would provide additional value to the research outcomes. Further, the question itself could have been improved by providing more details and not allowing the respondent to make their own assumptions about the situation surrounding the water use advisory.

When a situation of non-compliance with water quality guidelines occurs, it has to be managed in such a way as to avoid causing any harmful effects to public health. A suspension of the water supply could pose a greater risk than that from the consumption, for a limited period, of water with chemical concentrations exceeding the guideline values. Further, a water usage advisory or a suspension of the water supply is likely to result in decreased consumer confidence in the water utility and the safety of the drinking water supply.

In general, secondary risks are definitely considered by public health professional when recommending or issuing water use advisories. The significance of each of the secondary risks presented varied based on the assumptions made by the respondent regarding the availability of an alternate water supply or the type of the advisory (*i.e.*, boil water *vs.* do not use *vs.* do not consume) being issued and the duration of the advisory. For the secondary risks presented the following table summarizes how the respondents rated their significance:

Table 17. Question C6 Summary of Responses

Secondary Risk	Significance		
	Mean	Median	Mode
Inadequate personal hygiene	3.73	4	5
Inability to cook nutritious meals	1.77	2	2
Reduced water intake	2.5	3	3
Stress/fear and decreased confidence in water supply	3.5	4	4
Re-allocation of limited personal economic resources to purchase alternative, more expensive sources of water	2.4	2.5	3
Not washing produce	2.4	2	2
Not cleaning home or office	1.3	1	1
Personal Injury	2.7	3	3

Based on the responses, the two most significant secondary risks were considered to be inadequate personal hygiene and stress, fear and decreased confidence in the water supply. Other secondary risks that were provided by the respondents included: the public switching over to bottled water for the long term, obtaining water from an alternate, non-approved source, political risks, giving the public a false sense of security, and the potential impact on schools, healthcare facilities, restaurants and other public facilities. Of these, the respondents felt that the impact on health care facilities was very significant.

Question C7. How do water advisories impact the public's confidence in the water supply? Is this relevant to protecting the health of the public?

Twenty-one interviewees were specifically asked this question. In general, the respondents believe that water advisories can have either a positive or negative impact on the public's confidence in the water supply depending on the frequency, duration and overall management of the water advisory. An advisory always has the potential to negatively impact the public's confidence if it is not handled properly. If it is a repeat advisory, a long-standing advisory, lacks transparency, the importance is not preserved, lacks clarity in the details, or is poorly communicated, the public's confidence may be negatively affected.

The majority of respondents believe that public confidence in the water supply is relevant when protecting the health of the public because when public confidence in the water system or supply is weak, the public may be inclined to look for alternative, less-safe sources of water (*i.e.*, bottled water, well, *etc.*). Seven respondents specifically mentioned a positive association between decreased confidence in the water supply and an increase in bottled water use. One respondent indicated that water advisories may not be relevant to protecting the health of the public because when it comes to issuing an advisory we have a tendency to be motivated by politics and perceived risks rather than real risks.

One respondent indicated that a large portion of the public isn't aware when an advisory is issued, so in that regard, confidence does not change and they continue to drink the water. Many respondents made a distinction between the water utility or water supplier and the government agency providing monitoring and surveillance. When an advisory is issued the public's confidence in the health agency or group responsible for monitoring the water will most likely increase, whereas the confidence in the water supplier is more likely to decrease. As a result, there may be a tendency for utilities and water providers to be less up front when it comes to issuing an advisory. One respondent felt that there is nothing bad about slightly decreased confidence because it results in a public that asks more questions, challenges the water supplier and holds everyone more accountable.

The fact that many Canadians are willing to pay for additional home water treatment devices and bottled water may be indicative of a lack of confidence in the safety of public water supplies. Perhaps the ever growing list of trace contaminants in drinking water guidelines requiring monitoring and reporting is contributing to the decreased confidence.

Question C8. Health Canada's mandate and expertise lies in protecting the health of all Canadians by developing the *Guidelines for Canadian Drinking Water Quality*. How effective are the current guidelines at protecting the health of Canadians within your jurisdiction? How specifically do you know this? What evidence or observations demonstrate this?

Health Canada makes a substantial claim. If you visit its website, you will find a statement "Health Canada's mandate and expertise lies in protecting the health of all Canadians." It goes on to claim that it is accomplished "by establishing the *Guidelines for Canadian Drinking Water Quality*". It can be reasonably concluded that ensuring the safety and reliability of drinking water reduces risks to public health. However, whether guidelines do this alone is open to question. The objective of this question was to determine the role the guideline values in protecting the health of Canadians, according to public health professionals who are responsible for the application of the GCDWQ and to gather information on any evidence or observations that demonstrate the role of the GCDWQ.

Twenty-seven interviewees were specifically asked this question. The majority of respondents made remarks that supported the belief that the guidelines alone do not protect the health of all Canadians. Overall, respondents believe that the guidelines play a role in protecting the health of Canadians in the sense that they are applied and successfully promulgated and adopted. The guidelines assist in setting the overall framework for drinking water management and provide a reference point against which water quality can be measured. However, it is not the guidelines themselves but the use, interpretation and application of the guidelines that protects the health of Canadians, and they are only one piece of the overall approach. The guidelines are also considered effective because provincial and municipal programs have been developed based on them. Some respondents think that Health Canada should re-evaluate its mandate stating that the current mandate is broad and misleading because in reality, it is the responsibility of the provinces to protect the health of their citizens through intervention.

Most respondents indicated that there is a lack of evidence that demonstrates how effective the guidelines are at protecting the health of Canadians within its jurisdiction. The lack of evidence can be attributed to the complexity associated with conducting the necessary studies and the difficulty with relating prevalence of disease back to exposure via drinking water. Select respondents felt that improvements were needed in this area and feel it is important to collect the necessary evidence however difficult. Nine respondents indicated that the mere absence of illness attributed to drinking water suggests that the guidelines are protective of health. It was also suggested that taking the guidelines away may be the only way to evaluate just how effective they are.

One respondent suggested that in some instances, the guidelines may cause more harm than good when it comes to the health of the population. For example, to inform a pregnant woman that she consumed water contaminated with a substance that has been linked to miscarriage, without established evidence, you may be causing more harm in the way of undue stress and anxiety than the actual exposure to the chemical. In summary, it is generally believed that the guidelines themselves do nothing to improve public health if they are not being used effectively by public health professionals and provincial governments.

Question C9. Do you think that monitoring to indicate that physical, chemical, microbial, and radiological parameters in drinking water are below (within) the current *Guidelines for Canadian Drinking Water Quality* assures safe drinking water?

All 28 interviewees were specifically asked this question. Twenty-five respondents (89% of the participants) indicated that you can not rely exclusively on drinking water monitoring to assure safe drinking water. Three respondents responded "yes", two of which placed caveats around their response, one by stating that nothing is 100% safe and the other by indicating that you can only assure the safety of drinking water for the data you have at the time. In general the respondents believe that monitoring alone does not assure the safety of drinking water. The safety of drinking water can only be assured, at least to the extent possible, when monitoring programs are complimented with other elements of a multi-barrier approach, such as:

- Education and training
- Infrastructure, a good basic treatment, filtration and distribution system and constant awareness of its operation
- Source water protection

- Real-time, process monitoring

The respondents generally describe compliance monitoring as being nothing more than a quality assurance program, something that raises flags, but not all of them. Compliance monitoring is not a risk assessment and will always be limited by current science and technology. Although it does provide physical proof that water may be safe, the data can only be considered "icing on the cake", a mere indicator with many limitations. For these reasons, the respondents do not think that compliance monitoring alone can be relied upon to assure the safety of drinking water.

The respondents indicated there is a move away from reliance on compliance monitoring. However, one respondent indicted that one of the challenges with moving away from placing such a great emphasis on compliance monitoring is in the fact that numbers are what the public understand and want to see, and sometimes, numerical results are all they see.

Interview results are indicative of a greater awareness among health professionals that compliance monitoring is not a primary means for assuring safe drinking water. Most respondents are aware of the limitations of compliance monitoring. However, for various reasons public health professionals continue to rely on them, sometimes exclusively, to make risk management decisions. Issues facing compliance monitoring include:

- Not all systems require mandatory testing
- Not all parameters are tested for on a regular basis
- Sampling and analytical methods are not standardized so may not be comparing "apples to apples" (*i.e.*, dissolved *vs*. total measurements)

Many water supplies are not required to undergo mandatory testing, particularly for chemicals and there is no formal or recommended practice to determine what parameters to analyze for in any given water system or source. It was suggested that there should be an initial testing of every water supply for a broad suite of parameters combined with an assessment of potential sources of contamination (*i.e.*, agriculture activities, urban run-off, petroleum release sites, *etc*.). This risk assessment should then drive the future sampling program. The list of parameters in the GCDWQ should not "drive the process".

We do not need more testing to ensure the safety of our water, we need value-added testing. Testing at appropriate frequencies should be required and exemptions should be documented accordingly.

The amount of confidence public health professionals have in water quality monitoring results was surprising. Several respondents indicated that if a laboratory reports a value, then it is correct. When probed, very few respondents recognized the importance of QA/QC programs that may include trip, field or equipment blanks. It was apparent that public health professionals do not understand limitations of analytical data and how to verify or validate data they use in risk management decision making.

On its web site, Health Canada makes the following statements: "The Guidelines are recognized throughout Canada as the standard of water quality. They provide a convenient, reliable, yardstick against which water quality can be measured, so that problems can be quickly identified and corrected." and "The *Guidelines for Canadian Drinking Water Quality* are designed to provide Canadians with access to wholesome and safe drinking water". The problems with these statements are two-fold: first, a reasonable person may imply that collecting and analyzing water samples is convenient and reliable, essentially fool-proof, and second, that by meeting the guidelines the safety of drinking water is assured.

Question C10. Relative to other measures included in a multi-barrier approach to safe drinking water, how important are the specific guideline numbers (MACs) for ensuring safe drinking water?

The objective of this question was to evaluate the perceived role of guideline values in reducing public health risks relative to other measures that are included in a multi-barrier approach to safe drinking water. Twenty-four interviewees were specifically asked this question. The respondents were generally in consensus that the guidelines are only one part of a complex approach comprised of multiple barriers. However, most respondents had a difficult time determining exactly how important the specific guideline values are relative to the other elements within the multi-barrier approach. The respondents generally indicated that although the numerical guidelines are important, they are certainly not the most important element within the multi-barrier approach. It was also acknowledged that select guideline values play a more important role than other guideline values. For example, microbial guideline values would be considered more important than chemical guideline values because for most respondents sampling for chemical parameters is very infrequent.

However, it is generally believed that the guideline values are an essential element of a robust drinking water program. One respondent indicated that the multi-barrier approach is a result of having the guidelines. Others indicated that if all the elements of a multi-barrier approach are in place and working well, the relative importance of the guideline values decreases and they become "nothing more than action and communication values". As there continues to be a shift to rely more heavily on process monitoring and the continuous implementation of active barriers like training and source water protection, the relative importance of the numerical guideline values decreases accordingly.

Question C11. How much could chemical concentrations exceed a guideline before you would expect to see adverse health effects in the consuming population?

The objective of this question was to determine if risk management decision makers understand what guideline values mean in terms of health risks. Specifically, that the outcomes are predictions and that the guideline values are generally set up to 10,000 times below exposure levels at which adverse health effects are expected. Twenty-three interviewees were specifically asked this question and 74% responded with "I do not know" or "I have no idea". The respondents generally think that the amount a chemical could exceed a guideline value before adverse health effects would be expected depends on the specific parameter, the level of uncertainty built into the guideline value, the amount of water being consumed, whether the health effect is chronic or acute and the characteristics of the population exposed. One respondent used an analogy of a speed limit by stating "How much can you exceed the posted speed limit before you have an accident? We just do not know." For most chemicals we do not know what level of exposure will results in adverse health outcomes.

One respondent stated that if acceptable evidence exists to prove a guideline value is not appropriate, that evidence needs to be presented so informed individuals can use the information to evaluate the significance of a guideline exceedance. Three respondents believe that from a strict health outcome perspective it is likely tolerable to exceed a guideline value for a short period of time. However, from a liability perspective any exceedance, no matter how short or minor, could pose a problem. Others felt they could not answer the question because there is no way to know if illness results from an exceedance of a guideline value because we do not have any surveillance programs or mechanisms in place to monitor health outcomes.

In the face of uncertainty, public health professionals and regulators proceed with public health risk management decision making. This is typically justified using the precautionary principle. The European Union (EU) has detailed six guidelines as the basis for implementing the approach (European Commission [EC], 1998):

- Start with an objective risk assessment, identifying at each stage the degree of scientific uncertainty.
- All stakeholders should be involved in the decision to study the various management options that may be considered based on the results of the risk assessment. This process must be as transparent as possible.
- Implemented measures must be proportionate to the risk which is to be limited or eliminated.
- Measures must include a cost benefit evaluation with an eye to reducing the risk to a level that is acceptable to all stakeholders.
- Measures must establish responsibility as to who must furnish the scientific proof needed for a more comprehensive assessment of risks.
- Measures must be provisional in nature, pending the results of further scientific research.

The precautionary approach or principle was referenced several times throughout the interviews as justification for taking action to manage public health risks based on exceedances of numerical guideline values. Examples include:

- "We just take the precautionary approach."
- "…we issued [the advisory] as part of the precautionary approach…"

- "…they usually use the precautionary principle [when there are large uncertainties]…"
- "…most of the numbers we are using are being developed on the precautionary principle."
- "…we use the guidelines and apply precautionary approaches…"

Although, there is an understandable desire to be conservative and precautionary when it comes to public health protection, it must be understood by all stakeholders that the risk estimates used to derive the MACs, are predictions only. Therefore, just because a guideline value is exceeded, it does not necessarily mean that the exceedance will result in the adverse health outcome upon which the guideline value is based.

In consideration of the interview responses and the review of guideline development initiatives for THMs, it is apparent that there is failure to apply to some of the EU guidance. For example, the numerical guidelines are inherently precautionary so it is not necessary to be precautionary in their application. With respect to THMs, issuing a do not consume advisory based on a slight exceedance of the BDCM guideline for a short period of time is not a measure that would be considered proportionate to the risk being managed.

Only three respondents indicated that from a strict health outcome perspective it is likely tolerable to exceed a guideline value for a short period of time. Based on this, it does not appear that public health professionals understand what guideline values mean in terms of health risks. However, based on the responses in general it is reasonable to conclude that they understand the conservative nature of the guideline values but choose to be precautionary in their application for a number of reasons (*i.e.,* uncertainties, potential liability, due diligence, etc.).

Question C12. How do you believe the public expects you to implement drinking water guidelines?

This question was asked to help in determining how drinking water guideline values, as currently presented, impact public perceptions of drinking water health risks and the expectations of the public when it comes to the application of the guidelines. Twenty-eight of the interviewees were specifically asked this question. Nineteen respondents (68%) believe that the public expects the GCDWQ to be implemented as "hard and fast", regulatory standards that are law. Four respondents (14%) believe that for the most part, the public is not aware of the GCDWQ and they often take the safety of their drinking water for granted. Five respondents (18%) believe that the public expects more than the strict application of the guideline values and depending on who you are dealing with, they want to be informed and educated about several aspects of their drinking water supply so they can make their own informed decision.

Regardless of the expectations of the public, most respondents agree that it is difficult to explain guideline values and risk assessment and inherent limitations to the general public. With respect to the public, what causes fear and what causes illness are very different. The respondents indicated that several factors including the media, the guideline values, society, etc., influence the public's understanding of risks. Several respondents indicated that narrowing the gap between the public's understanding of risks (chance of illness) *vs.* their beliefs about risk (fear) will make it easier for regulators to effectively prioritize their efforts to reduce overall risks to public health.

Question C13. Do guideline values as currently presented to the public adequately portray the expected dose-response relationship and corresponding uncertainties?

Twenty-five interviewees were specifically asked this question. The majority of respondents do not think that the guideline values, as currently presented to the public, adequately portray the expected dose response relationship. However, the majority of respondents also appreciate the complexity of what goes into the numerical values and the difficulty in describing it. Select respondents believe that the guideline values and corresponding technical documents are highly academic and the general public does not have the level of knowledge that is required to understand risk assessment and corresponding uncertainties which are difficult to explain. As a result, many of the respondents felt that the current presentation of the guidelines often misleads the public into thinking that there is a distinct line that differentiates safe from un-safe. In fact, it was indicated that some public health professionals also rely on a line to differentiate safe from unsafe.

The responses further highlighted the belief that perhaps the public doesn't necessarily care about the dose-response relationship, they just want to know if their water is safe or not. A few respondents felt that there could be some improvements to the technical documents in terms of making them simpler to understand. One respondent even suggested that the guideline technical documents may even make things worse by confusing the public and causing fear and undue stress. No better way to present the guideline values was agreed upon by the respondents. Some felt that presenting them as a range would be useful, other felt that a range would cause more confusion. One respondent believes that the term MAC is part of the problem because it does not imply any uncertainty.

Question C14. If you observe an exceedance of a guideline value, what other types of evidence do you look at prior to taking action?

An important aspect of seeking safe drinking water is a capacity to make sensible decisions based on evidence (Rizak and Hrudey, 2007b). This question was asked in an attempt to identify what population-based, or other evidence is evaluated in conjunction with monitoring data and to determine if current information on the health of the population (*i.e.*, reported illness, incidence if disease, *etc.*) or epidemiological evidence is available for consideration during risk management. Nineteen interviewees were specifically asked this question. Upon observation of an exceedance of a guideline value the respondents generally indicated that they look at a variety of evidence or information prior to taking any action. In addition to consultation with other agencies, the community, the water supplier and the MOH, the following types of evidence are evaluated by the respondents:

- Any information pertaining to the treatment system and associated infrastructure to answer a variety of questions: Have they made any changed to treatment? Are there any new staff? Who collected the water sample? Where was the sample analyzed?
- Historical water quality data for the water supply
- The characteristics of the population served
- Reports of any complaints or compromises of the system (*i.e.*, line breaks, construction, *etc.*)

- Any other information that may support the water quality monitoring results (*i.e.*, local spill, new treatment process, sampling error, *etc.*)

In addition to the above evidence, when there is an exeedance or a positive result, it is common practice to collect additional samples from the treated water and analyze them to confirm the initial result

Prior to taking any action a few of the respondents indicated that there is consideration given to potential political implications. For those respondents who were specifically asked, they indicated that population health/surveillance data was not available to them to assist them with their risk management decision making. However, one respondent indicated that they may consult with local physicians or public health nurses to see if there are any patterns with respect to illness in the community (*i.e.*, physician billings, reported illness, *etc.*) and another respondent made reference to an enteric illness disease reporting system. Based on the responses it is apparent that good information, in terms of health surveillance data on the occurrence of illness associated with drinking water is limited. Without better data, it remains difficult to accurately identify health risks from drinking water and track any progress made in reducing these risks (Copes, 2006).

When making risk management decisions that have the potential to impact public health, monitoring data should not be relied upon in isolation. Additional supporting evidence that should be considered includes, but is not limited to: changes in environmental conditions, severe weather events (*i.e.*, heavy rainfall or runoff), changes in treatment, treatment failures, maintenance and repairs, distribution system changes or failures, laboratory QA/QC, and sample collection methods (Rizak and Hrudey, 2007a). This evidence and any other activity or condition that may impact water quality should be observed and documented at the time of sample collection (Rizak and Hrudey, 2007a). For those respondents who were specifically asked, they indicated that they are not aware of any formal system to document conditions at the time of sampling to enhance the evaluation of the data.

As such, the ability to effectively evaluate monitoring results in conjunction with other relevant evidence requires intimate knowledge of all aspects of the drinking water treatment system, its normal operating conditions and any factor that has the ability to compromise water quality at the time of sample collection. Unfortunately, the study was not designed to evaluate the knowledge level of individual public health professionals pertaining to the water treatment systems they oversee. However, based on the responses, most respondents seem very knowledgeable with respect to treatment processes and associated limitations in general.

The responses indicate that the majority of respondents recognize the importance of evaluating parallel evidence, particularly evidence related to water treatment system characteristics. However, it should be noted that while Rizak and Hrudey (2007a), recognize the limitations of repeat sampling of drinking water, the respondents do not. The main limitation is that water quality does not remain the same over time. Therefore, collecting additional samples for analysis to confirm positive results does not necessarily confirm that the initial result was correct. As such, re-sampling the water would only be an effective means of confirming test results for situations where there is on-going contamination. In order to provide the most value, repeat testing needs to be done on the same sample. However, current sampling and analytical methods for microbiological parameters are limited in that they do not allow for valid repeat analyses of the same sample (Rizak and Hrudey, 2007a).

Question C15. With the development of more guideline values and/or the lowering of current guideline values, what type of responses would you expect to see within the population?

Twenty-six interviewees were specifically asked this question. With a few exceptions, all respondents indicated that it is very unlikely that lowering numerical guidelines values would result in any noticeable improvement to the health status of the population. Although some believe that theoretically there would be less of a burden on the body and the water should be safer, any health improvements would be impossible to measure. The respondents generally indicated that if there were more numerical guideline values or current chemical guideline values were lowered, limited resources would be wasted on monitoring and sample analysis and escalating treatment costs. However, there would not necessarily be a noticeable improvement to the water quality or taste. Although the public would likely be receptive to what they would perceive to be an improvement of their water quality their attention would be diverted away from real health issues.

Based on the responses it is apparent that you can not measure improvements to public health if you do not know where you are starting. For example, we do not know how much cancer in the population, if any, can be attributed to chemicals in drinking water, so how could we ever know how many cancers we are preventing by meeting guideline values for chemicals in drinking water. We are a long way from having the ability to evaluate the effectiveness of public health outcomes resulting from adherence to chemical guideline values for drinking water. There is no comprehensive registry to track outbreaks or relate health outcomes to water quality data.

Improved drinking water safety does not necessarily mean lower numerical guideline values. However, much of the demand for more stringent drinking water protection measures has been misinterpreted to mean lower numerical guideline values and established guidelines for a greater number of chemicals. It was stressed by a handful of respondents that lower guideline values are not necessarily better for protecting public health because reducing acceptable concentrations of chemical contaminants in drinking water is not going to be effective in managing the most significant risks to consumers, disease-causing pathogens and a small number of chemical and physical parameters. Further, the growing demand for more stringent numerical chemical guidelines may be mistakenly interpreted to mean that the risks of waterborne illness have been adequately addressed (Copes, 2006). As such, shifting the focus to chemicals in drinking water may result in failure to adequately manage the risks posed by microbiological contaminants.

4.2.4 Section D: Comments and Recommendations

The general objectives of the following questions were to solicit recommendations for improvement, if any and to gather any additional comments relevant to the research study. Section D responses are summarized in Appendix E, Tables E27 through E31.

Question D1. In addition to what is already being done, do you have other expectations of Health Canada when it comes to establishing and implementing the *Guidelines for Canadian Drinking Water Quality?*

All 28 participants responded to this question. Six respondents do not have any further expectations of Health Canada when it comes to establishing and implementing the guidelines. In fact, two respondent challenged Health Canada's current involvement in stating that they have questionable authority to require a national scope on any matters related to health as public health is a provincial responsibility. The remaining respondents offered the following additional expectations of Health Canada:

- Improve and increase the frequency of communication
- Outline clearer expectations of the provinces for the implementation of the GCDWQ
- Develop a more holistic guidelines program that incorporates the multi-barrier approach
- Develop a risk assessment tool to assist in determining how the guidelines fit into the multi-barrier process,
- Improve the website, which is not user-friendly
- Take on a leadership role
- Actively solicit feedback from all stakeholders
- Improve the messaging around how the guidelines are meant to be used and implemented by developing an action plan or how-to guide
- Regularly re-visit the guidelines to ensure they are based on the most current information available
- Develop a clear standard for identifying and prioritizing evidence that can be used to make risk management decisions
- Place greater emphasis on stronger microbial treatment requirements
- Provide more training and education for those who are actually applying the guidelines

The most common expectation (identified by seven respondents) was improved communication, either with the public or with industry and stakeholders. Other common additional expectations of Health Canada included more education and training, guidance on guideline value application and to demonstrate leadership. The current efforts and good work of Health Canada was acknowledged by some respondents.

Question D2. Are there changes you would suggest regarding how to apply (*i.e.,* shut down a plant based on a single exceedance of any MAC) chemical guideline values to ensure that water quality guideline values provide the most benefit for all and achieve their intended aim?

Twenty-seven of the 28 interviewees provided an answer to this question. Several changes regarding how to apply chemical guideline values to ensure that they provide the most benefit for all and achieve their intended aim were suggested. The suggestions cover a broad scope. Common concepts and/or reasonable and significant suggested changes are summarized as follows:

- Provide more guidance on how to manage risks that may result from an exceedance of a numerical guideline value
- Provide real world scenarios for how to apply the MAC or a practical model (decision tree or flow chart) for risk management decision making
- Make it a mandate to achieve zero (*i.e.,* non-detectable concentrations) whenever possible, simply meeting the guideline value is not the best approach to take and should not be considered sufficient
- Make the guidelines more relevant to small systems and the people who are at risk, the farmers, the rural people, the small municipalities, and small co-ops
- Provide more guidance on how to communicate with the public when there is an exceedance of a guideline value
- Allocate resources and money to smaller systems to manage exceedances because they face greater risks than a municipality with significant funding and trained operators
- More effectively explain relative risk in terms of different practical scenarios within the technical documents
- Provide guidance on which parameters to look for (sample) within a system, which may include the development of a standardized risk assessment tool for identifying and prioritizing parameters of concern
- Provide more training for regulators regarding operational *vs.* health impacts
- Include provisions within the guidelines for emergency situations (*i.e.*, spills or

natural disasters, *etc.*)

- Provide more leadership
- Be more proactive in identifying potential threats to water safety (*i.e.*, environmental changes, global warming, climate change, *etc.*)
- Ensure a higher level of accountability for critical issues
- Provide solid public health evidence to justify the development of new guidelines or lowering guideline values
- Recognize that guideline values are only a small part of ensuring safe drinking water
- Establish a better pool or network of resources to help with managing risks from drinking water
- Utilize simpler, easier to understand language when discussing UFs and the rationalization of how the numbers are derived in the technical documents

Two respondents did not offer any suggested changes. One felt the guidelines, as currently presented, are adequate. The other respondent believes that no changes are required because health is not a federal matter and the application of the guidelines should be left to the discretion of provincial and municipal governments.

Question D3. Do you feel that you have received adequate guidance on the application of water quality guideline values? Who has/should provide this guidance? In what format was/should this guidance be provided? Formal (classroom, web-based) training, guidance documents, communication?

All 28 interviewees provided a response to this question. The majority (89%) of respondents do not feel they have received adequate guidance on the application of water quality guideline values and would welcome additional guidance from various sources. One respondent indicated that they had never received any formal training in risk assessment. It was generally recognized that there is a small amount of guidance within each technical document. However, many respondents felt that a greater amount of guidance has been offered pertaining to the application of bacteriological guidelines relative to other guidelines. Three respondents feel that they have received adequate guidance on the application of the guideline values. This guidance was generally sought out for themselves through experience and on-the-job training.

The respondents generally believe that the responsibility for providing this guidance belongs to RHAs, provincial health agencies and Health Canada and each of these agencies have roles to fill when it comes to providing additional training and education. It was suggested by some respondents that perhaps Health Canada could come to each province to offer additional guidance pertaining to the application of the guidelines. However, a handful of respondents do not believe that Health Canada's involvement in providing additional guidance is necessary as the provinces should develop their own guidance. In fact, one respondent indicated that it is better to have guideline development at an arms length from guideline application.

It was also suggested that additional guidance could be provided through educational institutions but it was believed by many respondents that RHAs have the ultimate responsibility for ensuring that their staff receive adequate training. In terms of additional guidance, it was also suggested that the provinces could appoint a provincial specialist to assist smaller health regions, who are in greatest need of more education for their health professionals. In general it was also stressed that there needs to be some responsibility on individuals who take on a public health role.

Based on the responses, additional guidance on the application of the guideline values should be provided in a variety of ways. However, just simply preparing and distributing additional guidance documents would not be considered sufficient as training needs to be continually reinforced. A handful of respondents felt that the guidance is available (*i.e.*, technical guidance documents, website, *etc.*), it is just up to individuals to educate themselves. It was also suggested that the public health agency of Canada should require post secondary institutions to review their curriculum for public health training programs and ensure that a higher level of risk assessment, communication, and management training and some of that directed specifically at environmental health guidelines is provided. Suggested forums for training include training sessions, workshops, video conferencing, on-line courses or distance learning, and/or publications/training materials.

It was recognized by some respondents throughout the interviews in general that too often, individuals rely on the numerical values and it is assumed that there is good science behind them. However, it is generally felt that having a greater level of knowledge and understanding of how the numbers are derived and the limitations may reduce the reliance on numerical guideline values, specifically, for chemicals. According to the respondents, the apparent lack of knowledge and understanding is primarily a result of the workload of most public health professionals. Public health professionals lack in-depth knowledge of how the guidelines are developed because they are involved in a variety of aspects related to public health protection (*i.e.,* food, housing, communicable diseases, animal control, *etc.*) and drinking water may only comprise 5% of their overall responsibilities. Therefore, the best way to ensure guidance is there when it is needed is to have a standing resource that is available to them when they require additional guidance. Respondents believe that Health Canada has a great deal of knowledge and expertise but fails to share it with those in the field, in a manner that is useful.

In summary, additional guidance on the application of the guidelines is necessary. Educational institutions need to be providing the appropriate courses and employers have a responsibility to hire people with the appropriate training and educational knowledge. Individuals must be presented with, and take advantage of, continuous professional development opportunities that provide them with the additional knowledge and experience to keep abreast within the field. Governments, especially Health Canada should provide more resources for the provision of training and education and awareness initiatives.

Question D4. What can Health Canada do or provide to ensure the consistent and reasonable application of guideline values?

In total, 24 interviewees were specifically asked this question and provided a response. General suggestions pertaining to what Health Canada can do or provide to ensure the consistent and reasonable application of the guidelines are summarized as follows:

- Improve communication at a variety of levels
- Share more information regarding the guideline development process and increase transparency, a better understanding of the limitations of the numerical guidelines will help to ensure the reasonable and consistent application of the guidelines

- Create learning opportunities and provide education to the agencies, the public and the water providers, including training on how to respond to issues like chemical exceedances
- Prepare some "how to" guides in an effort to provide a more practical interpretation of what the numbers mean and thus more consistency in their application
- Health Canada should explain how to apply and use a MAC so we can "stop abusing the precautionary principle" - there is a lack of understanding of it on many levels
- Obtain more health input on the CDW - currently mostly engineers
- Consider changing the presentation of the guidelines to include a primary objective as precautionary and a secondary objective as a "do not exceed" threshold and develop a different class of guideline for those parameters with significant UFs or limited health significance
- It would help to label select parameters as priority contaminants and priorities versus optional or tiered. It would be nice to have some tools to use that would give us an indication of what parameters we do need to test for.
- Ensure that owners of private systems know that they need to be testing their water, many assume the government is doing this for them
- Implement checks and balances into the system by sharing learnings across the country - health authorities are likely dealing with the same issues and could benefit by sharing knowledge
- Re-vamp the guidelines by emphasizing the critical issues and putting them at a higher level of regulatory accountability
- Remain critical about what parameters are significant enough to bring in as guidelines to ensure resources are not wasted on monitoring for an endless number of chemicals

During discussion, many respondents were asked how important consistency is in the application of the guideline values. Of the 13 respondents who were specifically asked, each of them felt consistency was very important. It was suggested that inconsistency in the application of the guidelines is often a direct result of a lack of understanding and knowledge and points to the need for further training. It was generally believed that inconsistency erodes public confidence and discredits public health professionals and the validity of the guidelines. Although it was suggested that national standards could bring a certain level of consistency, it was widely acknowledged that national standards would not be beneficial and would fail to provide the required flexibility necessary to address the diversity of the regions and the variety of issues facing individual drinking water systems.

In summary, the reasonable and consistent application of the guideline values can be ensured by implementing the most common suggestions: improve communication; improve the presentation of the guidelines by placing greater emphasis on high priority parameters, improve the level of understanding and knowledge of public health professionals regarding the development process and offer more practical guidance on the application of the guidelines.

Question D5. Additional Comments:

Additional comments are summarized in Appendix E, Table E31. Many of the additional comments have already been discussed throughout this section.

4.3. Limitations of Research Findings

Given the qualitative nature of the data collection method, it is important to highlight limitations of the data and recognize what impact these limitations may have on the study findings. Specifically, the following characteristics of the study design present challenges when trying to draw definitive conclusions from the interview results:

- a mix of standardized, open-ended questions and closed-, fixed-response questions were utilized;
- the sample size was relatively small;
- interviews required a significant amount of the participant's time;
- questions were asked according to how the interview developed, not every interviewee was asked each question and questions were not necessarily presented in the same order during each interview;

- questions were phrased according to what was considered appropriate at the time, drawing on relevant examples from preceding discussions between the interviewee and the researcher.

Interviewer bias is a reality of research studies that utilize interviews to gather data (Patton, 2002). The quality of the data collected is largely influenced by the exact phrasing of individual questions. Therefore, an effort was made to maintain a certain level of consistency between interviews. However, during the research it was up to the interviewer to determine how much or how little information to offer to the participant and how much to probe.

Because respondents were free to answer in any manner they felt appropriate, the level of detail in the responses is not consistent between respondents. The level of detail and validity of any given response may depend on the respondent's interpretation or understanding of the question, the amount of trust between the researcher and interviewee (particularly for questions that may be sensitive in nature), emotions (*i.e.,* being nervous or distracted), the respondents interpretation of the value of the study question, and/or forgetfulness. The inconsistencies in the responses and the variable amounts of detail provided make it difficult to compare results. If the participant was too busy, they may have not prepared and other participants may have prepared more. Those with a better understanding of the topic generally offered more explanations and justifications for responses. Also, it was apparent that depending on recent issues and experiences, the amount of information provided in certain responses varied considerably as did the types of examples provided to demonstrate points. Further, those participants who had recent experience with a drinking water-related issue had more constructive criticism to offer pertaining to the specific topic.

Although the majority of interviews were conducted one-on-one, two participants were interviewed simultaneously. Therefore, their responses may be subject to potential influences from one another (Patton, 2002). However, this was limited to only one pair of respondents and the responses from these two participants were treated in the same manner as the other responses.

The flexible interview approach proved valuable in that a large amount of detail was provided in the responses. However, the interpretation of results depends on the level of understanding of the responses by the interviewer and their interpretation of the relevance of the responses (Patton, 2002). Inevitably, personal discretion and judgments were applied during data interpretation and presentation.

In consideration of the inherent limitations associated with the qualitative nature of the research, common themes within the responses were identified and interpreted. Therefore, the results provide valuable insight into the specific issue being researched, can be used to support or refute the hypothesis and subsequently form a basis for making recommendations. In the context of this research project, given the breadth of information collected, the interview responses provide an in-depth evaluation of the practical, analytical and interpretive aspects of guideline value application.

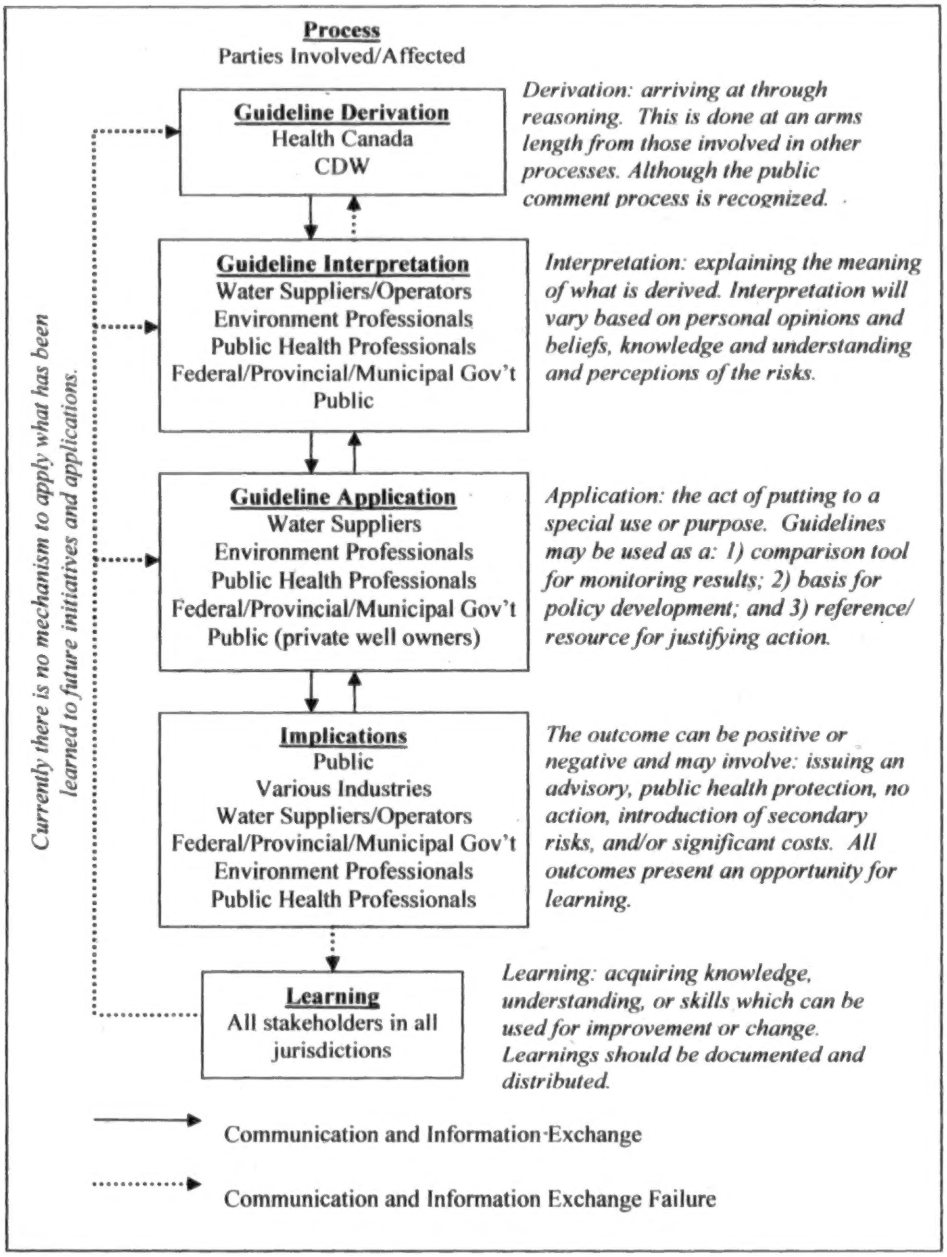
5. Discussion and Analysis

A discussion of the key research findings is presented within this section. One of the significant realizations throughout this process was the apparent disconnect between those who develop the guidelines, those who interpret them, those who apply them and those who experience the implications of the actions taken (or not taken). This is represented in Figure 9. Further, it is apparent that the lessons learned through the application of the guidelines are not captured and shared in an effort to make needed improvements.

Risk management decision making, based on the GCDWQ as currently presented, could become more proactive and consistent, and thus possibly more effective if the following concepts are incorporated into the guideline program:

1. The numerical guideline values need to be developed in consideration of the most significant risks to drinking water: microbiological contaminants and priority substances. The resulting presentation of the guideline values (both written and web) should reflect this relative prioritization. Although Health Canada has been developing the necessary tools, this is not yet evident on the Health Canada website for the GCDWQ (D'Costa *et. al.*, 2006). Microbial water quality is critical and must not be compromised in an attempt to manage risks from chemicals, such as DBPs.
2. Chemical parameters most likely to occur, and for which there is established evidence of causing human health impacts via drinking water, should be given priority when developing water quality monitoring programs and requirements. A hierarchy for routine monitoring of drinking water has been conceptualized by Health Canada but remains to be implemented (D'Costa *et. al.*, 2006).
3. The numerical guideline values and corresponding technical documents should more adequately recognize and address the "real world" scenarios to which they are applied and the associated complexities. For example, chemical guideline values need to recognize the infrequent and localized nature of most chemical contamination events of drinking water supplies and include provisions for how to best manage risks under those circumstances. Explaining, where possible, the relative risk in terms of different exposure scenarios (*i.e.*, 5 mg/L for two weeks

Figure 9. From Guideline Derivation to Lessons Learned


Process
Parties Involved/Affected
Guideline Derivation
Health Canada
CDW
Guideline Interpretation
Water Suppliers/Operators
Environment Professionals
Public Health Professionals
Federal/Provincial/Municipal Gov't
Public
Guideline Application
Water Suppliers
Environment Professionals
Public Health Professionals
Federal/Provincial/Municipal Gov't
Public (private well owners)
Implications
Public
Various Industries
Water Suppliers/Operators
Federal/Provincial/Municipal Gov't
Environment Professionals
Public Health Professionals
Learning
All stakeholders in all jurisdictions
Currently there is no mechanism to apply what has been learned to future initiatives and applications.
Communication and Information Exchange
Communication and Information Exchange Failure

Derivation: arriving at through reasoning. This is done at an arms length from those involved in other processes. Although the public comment process is recognized.

Interpretation: explaining the meaning of what is derived. Interpretation will vary based on personal opinions and beliefs, knowledge and understanding and perceptions of the risks.

Application: the act of putting to a special use or purpose. Guidelines may be used as a: 1) comparison tool for monitoring results; 2) basis for policy development; and 3) reference/ resource for justifying action.

The outcome can be positive or negative and may involve: issuing an advisory, public health protection, no action, introduction of secondary risks, and/or significant costs. All outcomes present an opportunity for learning.

Learning: acquiring knowledge, understanding, or skills which can be used for improvement or change. Learnings should be documented and distributed.

vs. 5 mg/L for 70 years) may also be valuable for public health professionals. Relatively few short term exposures to chemicals in drinking water have caused acute health effects. When chemical contamination does occur the water usually becomes undrinkable due to unacceptable taste, odour or appearance before it becomes a significant health risk (WHO, 2004).

4. Public health professionals could benefit from more training on all aspects of guideline development to increase their knowledge and level of understanding of the process and the challenges. Additional knowledge may assist in bridging the communication gap between those who develop the guidelines and those who apply them and may also improve consistency in the application of guideline values across regions. Additional knowledge may also assist in improving the perceived transparency of the guideline derivation process and public health professionals will be in a better position to challenge the *status quo* of that process.

5. Failure to adequately characterize and quantify uncertainty makes it difficult for public health professionals to make the most appropriate risk management decision. This can become even more difficult if a number of risk management options are available to choose from. In the guideline documents themselves it is critical that sources of uncertainty and variability be specifically called out in each step of the risk assessment. An explanation of how uncertainty and variability have been addressed in the derivation of the guideline value and what the expected implications are for the application of the guideline would be valuable.

6. Individual drinking water quality monitoring programs need to be appropriate for the system they are applied to. Steps need to be taken to minimize unnecessary monitoring and consistently require critical monitoring to effectively evaluate drinking water quality. Priorities need to be established that allow public health protection but prevent the diversion of limited resources to monitoring substances of relatively minor importance or those that may not be found. For example, it needs to be recognized that monitoring programs do not provide the means to detect intermittent chemical contamination events (*i.e.,* fuel spill) or isolated treatment system failures because they are infrequent.

7. To assist the public and public health professionals in becoming better informed

and to minimize confusion, Health Canada should allocate resources to improve and up-date its web site and technical materials that describe the derivation process. The information contained within *Approach to the Derivation of Drinking Water Guidelines* and *Canadian Drinking Water Guidelines Development Process* (Health Canada, 1995 and 1999) is not consistent with what is currently being done.

8. Those in the water industry should continue to evaluate better ways (*i.e.*, more accurate, more cost effective, *etc.*) to collect and analyze water quality data. For example, perhaps there is a way to use real-time monitoring to assist in eliminating some of the uncertainties pertaining to sample collection and therefore, use real-time monitoring of surrogate parameters to help collect more representative samples for parameters that cannot be monitored continuously.
9. Steps need to be taken to reduce the gap between the public's understanding of risk (illness) *vs.* perceived risk (fear). A better informed public will facilitate the ability of public health professionals to prioritize efforts to reduce overall risks to public health. The public should be further informed on several aspects of the guideline development process, the assumptions made and implications for the application of the guideline values, including secondary risks.

As proposed by Hrudey (2005), the findings of the current research appear to support the premise that the drinking water guideline program in Canada is not consistent with a population health approach. In an effort to move toward a preventive total risk management approach aimed at improving the health of the population, similar to approaches adopted in Australia, New Zealand and the WHO, a number of improvements should be considered:

1. In order to adequately protect the public, the GCDWQ need to encompass a more holistic approach for managing potential risks from un-safe drinking-water. As currently presented, the GCDWQ primarily provide a check on the final quality of treated tap water. In reality, the safety of a water supply is most effectively protected by the successful implementation of multiple barriers. Accordingly, guidelines should be developed for each element of the multi-barrier process. More emphasis on the entire drinking water system, rather than just numerical values for specific parameters, is required. The focus needs to be shifted to the

development and implementation of best practice guidelines that can be applied to all aspects of drinking water quality management and treatment.

2. Reliance on compliance monitoring to ensure the safety of drinking water should be de-emphasized. This message needs to be conveyed to those in the drinking water industry and the public. Historically, much of the focus is on monitoring finished water because it is a relatively easy measure of water quality and the primary focus of Health Canada has been on developing numerical (MAC) drinking water quality guidelines. The GCDWQ set the foundation that forms the basis for the culture within individual water treatment systems. If the national focus is only on numbers, then that focus will likely cascade throughout the industry. Currently the guidelines start "small", focusing on only one element of drinking water safety. They need to be broadened to encompass all aspects of drinking water safety and be presented accordingly. As acknowledged by Health Canada (CCME, 2004), the thinking around compliance monitoring needs to change. The realization that the monitoring of treated drinking water, alone is not enough to assure safe drinking water needs to be put into practice. Therefore, the GCDWQ, should be reflective of this.

3. The following claim is made on the Health Canada website: "Health Canada's mandate and expertise lies in protecting the health of all Canadians by establishing the *Guidelines for Canadian Drinking Water Quality*". This mandate needs to be reevaluated. It is fair to conclude that ensuring the safety and reliability of drinking water reduces risks to public health. However, as demonstrated by the research findings, establishing the guidelines by itself does not ensure the safety and reliability of drinking water.

4. The drinking water industry, including Health Canada, various levels of government and individuals, all need to be learning from past experiences to prevent future failures. How do we learn and improve if we are not sharing the lessons we are learning? It is reasonable to expect that we should learn from our mistakes. In fact, failure to do so could be considered negligent. In occupational health and safety practice, negligence is demonstrated when a similar event that has happened in the past occurs a second time (CCOHS, 2008). It is important to know and understand what other stakeholders in the industry are doing and the

types of issues they are facing and identify commonalities. Risk management should be attempting to apply those lessons to prevent failures rather than merely react to them (Rizak and Hrudey, 2007b).

5. The solution to developing the best possible guideline values is to standardize the process by which risks are assessed and to ensure the consistent use of a sound scientific process that is both defensible and justifiable. The technical support documents for the GCDWQ have attempted to do this, but their content is not clear enough nor generally understood by public health professionals. Every effort has to be made to ensure that this is, and continues to be, the case for the derivation of the GCDWQ.

As recognized by the Australian drinking water community, the most effective means of assuring drinking water quality and the protection of public health is through the implementation of a preventive management approach that encompasses all steps in water production from source to end-of-tap (NHMRC, 2004). In line with this, there needs to be a national framework, beyond what is currently available in Canada that sets the foundation for the development of drinking water safety programs at the national level. Such a framework should consist of a number of elements and within each element, specific expectations of all stakeholders and corresponding performance metrics should be specified. Stakeholders should be able to apply these metrics to their drinking water systems in a practical sense. The development and application of numerical guideline values would be one element within a more holistic drinking water management system. The following elements, adapted from the Australian Guidelines are considered essential to the continuous delivery of safe drinking water (NHMRC, 2004):

1. Leadership and Commitment – develop a set of expectations to ensure the accountability and active involvement of all stakeholders.
2. Training and Competency – develop a set of expectations to ensure the recruitment, training, and placement of competent personnel.
3. Treatment and Disinfection – develop a set of expectations to ensure the continued optimization and control of operational equipment and processes.
4. Incident Analysis and Communication of Lessons Learned – develop a set of

expectations to ensure the timely reporting, investigation, follow-up and communication of all incidents. Lessons learned would be shared with various stakeholders to prevent similar failures in the future.

5. Risk Management – develop a set of expectations to ensure that all foreseeable risks are systematically and consistently identified, evaluated and appropriately managed in consideration of the nature and magnitude of the risk. Risk management plans or programs should be applied to all existing, new and proposed systems and water sources.
6. System Protection – develop a set of expectations to ensure that appropriate and adequate controls are in place to protect the system (*i.e.*, source water, distribution lines, *etc.*)
7. Change Management – outline expectations that would ensure that change is recognized and any potential impacts on drinking water safety are identified and evaluated and managed in accordance with risk management processes
8. Emergency Response Management – establish expectations to ensure that potential emergency situations are identified and emergency management plans (that includes provisions for training and equipment) are developed, communicated and implemented, as required.
9. Monitoring – establish expectations for the verification of drinking water quality through process and compliance monitoring. Expectations for data validation and QA/QC must be included.
10. Customer Satisfaction – establish expectations to ensure customer needs are understood, their expectations are exceeded met and they have an opportunity be engaged through open dialogue.
11. Continuous Evaluation and Improvement – outline expectations to ensure the ongoing evaluation (*i.e.*, audits and assessments) and continuous improvement of system performance.
12. Supporting Elements – outline expectations for research and development and other considerations necessary to support the proposed framework.

It is recognized that several of the above concepts are included within Canada's multi-barrier approach to safe drinking water (CCME, 2004). However, as currently presented, the available guidance on the multi-barrier approach is lacking in some aspects. The biggest limitation is that the multi-barrier approach is not incorporated directly into the GCDWQ. In addition, relative to the Australian guidelines, available guidance on the multi-barrier approach is missing practical metrics that can be used by stakeholders and effectively applied to drinking water systems for tangible benefit. For example, with respect to prioritizing risks, the Australian Guidelines, although not overly prescriptive, provide examples of the types of risks to consider (*i.e.,* maximum vs. residual) and a qualitative risk analysis matrix, among other useful tools to be used by stakeholders (NHMRC, 2004). In contrast CCME (2004) states:

> "Many jurisdictions in Canada are developing procedures for prioritizing risks to drinking water from source to tap. For more information on how this is being done in your jurisdiction, contact your provincial or territorial drinking water authority."

The tools and metrics presented within the Australian Guidelines will likely go a long way in ensuring the consistent and reasonable prioritization of risks for all stakeholders. On a larger scale, the Australian Guidelines promote a standard approach to managing all aspects of drinking water safety that can be applied throughout the industry, which establishes due diligence and credibility (NHMRC, 2004). Perhaps a formalized collaboration between relevant parties in Canada and Australia could move this concept further.

6. Conclusions

Public health professionals are very dedicated and have an appreciable amount of training and knowledge, based on work experience and education. However, for several individuals only a relatively small portion of formal training and work experience has been directly related to drinking water risk management. This is understandable given the diverse nature of the issues public health professionals are trained to recognize, evaluate and control.

Public health professionals with responsibility for assuring the safety of drinking water primarily use the GCDWQ as: 1) a comparison tool for evaluating water quality; 2) a reference guideline upon which to base and justify risk management decisions; and/or 3) a technical resource to guide local policy development initiatives. In general, public health professionals consider the GCDWQ and supporting technical documents to be useful in their application and a good resource, although some improvements are considered necessary.

Although some direction is provided by local governments and five provinces/territories have incorporated the specific GCDWQ into legislation, the interpretation and subsequent application of the GCDWQ is primarily left up to individual public health professionals. Therefore, the application of the GCDWQ is largely dependent upon individual interpretations of relevant risk management principles and concepts and the level of knowledge and understanding of individual public health professionals regarding the guideline development process and inherent limitations.

Several risk management principles and concepts have significant implications for the application of the GCDWQ. These can be summarized as:

- Uncertainty and variability are inevitable limitations of risk assessment that are accounted for through the use of very conservative assumptions. Establishing guideline values is an exercise in caution.
- Water quality monitoring data have several practical and conceptual limitations and water quality monitoring alone does not assure safe drinking water.
- Applying a certain level of precaution is an important and justifiable element of

public health risk management.

- There is no such thing as zero risk, there are only risk trade-offs. Secondary risks can be significant and should be considered.
- Risks associated with disease-causing microorganisms are greater than those typically posed by chemicals in drinking water.
- Not all chemical contaminants should be treated the same. Most of the risk from chemicals in drinking water is associated with only a few key contaminants.

Based on the interviews conducted, the following conclusions pertaining to guideline development, knowledge and application and drinking water risk management have been made:

- Public health professionals seem to have only a moderate level of knowledge and understanding regarding the guideline development process. In fact, 20% of respondents claim to have no knowledge of the guideline development process.
- Overall, the full extent of uncertainty involved in guideline value derivation and the resulting implications for the application of the numerical guideline values is not sufficiently recognized by those who apply the guidelines. More than 25% of respondents do not know how uncertainty is addressed in the guidelines. Therefore, they generally tend to underestimate the level of conservatism built into the guideline value. However, most respondents seem to have a good understanding of UFs and what they tell us about the resulting guideline value.
- Public health professionals do not seem to have a solid understanding of the differences between carcinogenic and non-carcinogenic risk assessment approaches and there is confusion regarding the relevance of the mode of action of carcinogens (*i.e.,* assumed threshold for non-genotoxic or epigenetic carcinogens).
- Defining safe drinking water is a challenge and there is a lack of consistency in how public health professionals define safe drinking water. Although, several key elements are identified, unrealistic zero risk concepts are also included in several of the respondent's definitions of safe drinking water. There is no common working concept of safe drinking water.
- Practical and conceptual limitations of compliance monitoring seem to be well understood by most public health professionals and the concept that monitoring

alone does not assure safe drinking water is generally supported.

- When comparing chemical and microbial risks, it is widely acknowledged that microbial risks are greater than those posed by chemicals. Accordingly, day-to-day, a greater emphasis is placed on ensuring the microbial safety of drinking water, relative to the chemical safety of drinking water.
- It was widely acknowledged among respondents that not all chemical contaminants should be treated equally. The level of attention should depend on a number of factors and be determined through a system-specific risk assessment process.
- The majority of respondents (almost 60%) do not believe that the GCDWQ are presented in a way that adequately reflects the relative level of attention warranted by different parameters.
- Overall, it was not widely recognized that very few chemicals have established evidence of causing human health impacts via drinking water. In fact, some respondents indicated that established evidence about the nature of risk to human health posed by any contaminant is irrelevant because once a guideline value is established, due diligence requires that it be applied. Concern for exercising due diligence and precautionary principles are important considerations that drive the behaviour of field personnel. As such, this behaviour needs to be considered when evaluating the role and effectiveness of the GCDWQ.
- Public health professionals are very aware of secondary risks associated with water use advisories and are able to prioritize these risks reasonably and consistently.
- Public perceptions, attitudes and beliefs towards drinking water are influenced by the development and implementation of the GCDWQ. The majority of respondents (68%) believe that the public expects the GCDWQ to be used as binding standards.
- The respondents generally believe that the guidelines alone do not ensure the health of Canadians. Rather, it is the interpretation and application of the guidelines, in conjunction with other elements in a multi-barrier approach that protects the health of the public.
- Other than the absence of water borne disease outbreaks, there is little evidence available to demonstrate the effectiveness of the GCDWQ in protecting public

health.

- Most respondents have enormous confidence in water quality monitoring results and generally fail to recognize potential limitations of monitoring results reported by laboratories.
- When evaluating an exceedance of the GCDWQ, public health professionals evaluate several other types of evidence (*i.e.*, historical data, treatment system details, additional data, *etc.*) prior to taking action. However, they fail to recognize the limitations of repeat sampling to confirm a positive monitoring result. Because water quality changes over time, a subsequent positive result does not necessarily confirm that the initial result was correct.
- Respondents do not generally believe that the implementation of more stringent numerical guideline values will translate into improved public health.
- The majority of respondents do not believe that they have received adequate guidance on the application and use of the GCDWQ.
- Many respondents believe that clarification is required regarding how the guidelines fit into the overall multi-barrier approach to safe drinking water.

Respondents outlined a number of expectations of Health Canada and offered several recommendations that may help to ensure that the GCDWQ provide the most benefit for all and achieve their intended aim of public health protection. The current effort and good work by Health Canada, provincial governments and several individuals was acknowledged.

Generally, findings from the interview responses and the review of relevant literature offer support of the hypothesis that failure to establish a clear framework and set of priorities for guideline value development and application has resulted in some cases of reactive and inconsistent risk management decision making. There appears to be a significant disconnect between those who develop the guidelines and those who apply them. Further, there is an apparent failure to capture learnings and apply lessons learned to future guideline development and risk management initiatives.

In summary, Health Canada is missing an important opportunity with the guidelines program in Canada by offering only what functions as a "one-size-fits all" approach to drinking water safety. The water systems and specific events that the GCDWQ are applied to vary considerably. By not elaborating on the inherent and major complexities and uncertainties in the guideline value derivation process and failing to acknowledge the diverse nature of drinking water systems the guidelines may not be applied effectively in the field. There is a need for a focused program to feed experience from field applications of the GCDWQ back into the process of deriving them. The result should explain how the GCDWQ can be used most effectively in typical field applications.

It should be noted that the above conclusions are based on information gathered from public health professionals. Realizing that public health professionals are not the exclusive users of the GCDWQ, there are likely additional considerations for representatives of various environmental departments.

7. Recommendations

A clearer framework and set of priorities may be realized with the implementation of the following recommendations.

1. The GCDWQ should be expanded to incorporate all aspects of drinking water safety, not just numerical guideline values.
2. The limitations of risk assessment resulting from uncertainty and variability must be better understood, acknowledged and given appropriate consideration in the development and subsequent application of guideline values. Additional training and education pertaining to the guideline development process would be valuable.
3. The numerical guideline values need to be developed and presented in consideration of the most significant risks to drinking water: microbiological contaminants and priority substances.
4. The numerical guideline values and corresponding technical documents should more adequately recognize and address the "real world" scenarios to which they are applied and the associated complexities. Experience gained from the field application of the GCDWQ needs to be fed back into the derivation process.
5. Health Canada should demonstrate more leadership with respect to drinking water safety in Canada. Although Health Canada does not exercise jurisdiction to implement drinking water programs, they are not barred from developing a framework or template with the provinces for all to work from. This leadership would likely help to improve the effectiveness, consistency and overall integrity of drinking water safety programs throughout Canada.

The continued efforts and noticeable progress made by Health Canada representatives and recent improvements to the federal guidelines program are acknowledged. Moving forward, it is important that every effort be continually made to ensure the consistent use of a sound scientific process that is widely understood, defensible and justifiable for the derivation of numerical guideline values contained within the GCDWQ. The valuable knowledge that public health professionals have gained from practical experience should be considered and utilized, where appropriate, in the development of drinking water guidelines.

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9. Appendix A: Guidelines for Canadian Drinking Water Quality

Table A1. Microbiological Guidelines

Parameter	MAC	Guideline/Comment
Bacteria		
Escherichia coli	None detectable per 100 mL	--
Total Coliforms	None detectable per 100 mL	--
Heterotrophic Plate Count Bacteria	Not specified	Concentrations above baseline levels are considered undesirable.
Emerging Pathogens	Not established	Emerging bacterial waterborne pathogens include, but are not limited to, *Legionella*, *Mycobacterium avium* complex, *Aeromonas hydrophila*, and *Helicobacter pylori*.
Protozoa	Not established	Treatment technologies in place should achieve at least a 3-log reduction in and/or inactivation of cysts and oocysts, unless source water quality requires a greater log reduction and/or inactivation.
Viruses	Not established	Treatment technologies and watershed or wellhead protection measures known to reduce the risk of waterborne outbreaks should be implemented and maintained if source water is subject to fecal contamination or if enteric viruses have been responsible for past waterborne outbreaks. Where treatment is required, treatment technologies should achieve at least a 4-log reduction and/or inactivation of viruses.
Turbidity	Not established	Waterworks systems that use a surface water source or a groundwater source under the direct influence of surface water should filter the source water to meet the following health-based turbidity limits, as defined for specific treatment technologies. Where possible, filtration systems should be designed and operated to reduce turbidity levels as low as possible, with a treated water turbidity target of less than 0.1 NTU at all times. Where this is not achievable, the treated

Table A1. Microbiological Guidelines

Parameter	MAC	Guideline/Comment
		water turbidity levels from individual filters: 1. For chemically assisted filtration, shall be less than or equal to 0.3 NTU in at least 95% of the measurements made, or at least 95% of the time each calendar month, and shall not exceed 1.0 NTU at any time. 2. For slow sand or diatomaceous earth filtration, shall be less than or equal to 1.0 NTU in at least 95% of the measurements made, or at least 95% of the time each calendar month, and shall not exceed 3.0 NTU at any time. 3. For membrane filtration, shall be less than or equal to 0.1 NTU in at least 99% of the measurements made, or at least 99% of the time each calendar month, and shall not exceed 0.3 NTU at any time. If membrane filtration is the sole treatment technology employed, some form of virus inactivation should follow the filtration process.

Table A2. Chemical and Physical Parameters With Established MACs

Parameter	MAC (mg/L)	Year of approval (or reaffirmation)
Aldicarb	0.009	1994
Aldrin + dieldrin	0.0007	1994
*Antimony[b]	0.006	1997
Arsenic	0.010	2006
*Atrazine + metabolites	0.005	1993
Azinphos-methyl	0.02	1989 (2005)
Barium	1	1990
Bendiocarb	0.04	1990 (2005)
Benzene	0.005	1986
Benzo[a]pyrene	0.00001	1988 (2005)
*Boron	5	1990
*Bromate	0.01	1998
Bromodichloromethane	0.016	2006
*Bromoxynil	0.005	1989 (2005)
Cadmium	0.005	1986 (2005)
Carbaryl	0.09	1991 (2005)
Carbofuran	0.09	1991 (2005)
Carbon tetrachloride	0.005	1986
Chloramines--total	3	1995
Chlorpyrifos	0.09	1986
Chromium	0.05	1986
*Cyanazine	0.01	1986 (2005)
Cyanide	0.2	1991
Cyanobacterial toxins-Microcystin-LR	0.0015	2002
Diazinon	0.02	1986 (2005)
Dicamba	0.12	1987 (2005)
*1,2-Dichloroethane	0.005	1987
1,1-Dichloroethylene	0.014	1994
Dichloromethane	0.05	1987
*2,4-Dichlorophenoxyacetic acid (2,4 -D)	0.1	1991
Diclofop-methyl	0.009	1987 (2005)
*Dimethoate	0.02	1986 (2005)
Dinoseb	0.01	1991
Diquat	0.07	1986 (2005)
Diuron	0.15	1987 (2005)
Fluoride	1.5	1996
*Glyphosate	0.28	1987 (2005)
Lead	0.01	1992
Malathion	0.19	1986 (2005)
Mercury	0.001	1986
Methoxychlor	0.9	1986 (2005)
*Metolachlor	0.05	1986
Metribuzin	0.08	1986 (2005)

Table A2. Chemical and Physical Parameters With Established MACs

Parameter	MAC (mg/L)	Year of approval (or reaffirmation)
Nitrate[f]	45	1987
Nitrilotriacetic acid	0.4	1990
*Paraquat (as dichloride)	0.01	1986 (2005)
Parathion	0.05	1986
Phorate	0.002	1986 (2005)
*Picloram	0.19	1988 (2005)
Selenium	0.01	1992
*Simazine	0.01	1986
*Terbufos	0.001	1987 (2005)
Tetrachloroethylene	0.03	1995
Trichloroethylene	0.005	2005
*Trifluralin	0.045	1989 (2005)
Trihalomethanes-total	0.100	2006
Turbidity	0.3/0.1/0.1 NTU	2004
*Uranium	0.02	1999
Vinyl chloride	0.002	1992

Note (s): Parameters for which the health-based guideline was developed as an interim MAC are marked with an asterisk (*). Units are expressed as milligrams per litre (mg/L), unless otherwise specified. NTU = nephelometric turbidity units.

Table A3. Chemical and Physical Parameters With Established MACs and AOs or OGs

Parameter	MAC (mg/L)	AO [or OG] (mg/L)	Year of approval (or reaffirmation)
1,2-Dichlorobenzene	0.2	≤0.003	1987
1,4-Dichlorobenzene	0.005	≤0.001	1987
2,4-Dichlorophenol	0.9	≤0.0003	1987 (2005)
Monochlorobenzene	0.08	≤0.03	1987
Pentachlorophenol	0.06	≤0.030	1987 (2005)
2,3,4,6-Tetrachlorophenol	0.1	≤0.001	1987 (2005)
2,4,6-Trichlorophenol	0.005	≤0.002	1987 (2005)

Table A4. Chemical and Physical Parameters With AOs or OGs

Parameter	AO [or OG] (mg/L)	Year of approval (or reaffirmation)
Aluminum	[0.1/0.2]	1998
Chloride	≤250	1979 (2005)
Colour [1]	≤15 TCU	1979 (2005)
Copper	≤1.0	1992
Ethylbenzene	≤0.0024	1986 (2005)
Iron	≤0.3	1978 (2005)
Manganese	≤0.05	1987
Methyl tertiary-butyl ether (MTBE)	0.015	2006
Odour	Inoffensive	1979 (2005)
pH	6.5-8.5	1995
Sodium	≤200	1992
Sulphate	≤500	1994
Sulphide (as H_2S)	≤0.05	1992
Taste	Inoffensive	1979 (2005)
Temperature	≤15°C	1979 (2005)
Toluene	≤0.024	1986 (2005)
Total dissolved solids	≤500	1991
Xylenes--total	≤0.3	1986 (2005)
Zinc	≤5.0	1979 (2005)

1. TCU = true colour unit.

Table A5. Parameters Without Established Guideline Values

Ammonia	Asbestos	Calcium
Formaldehyde	Gasoline	Hardness
Magnesium	Radon	Silver

Table A6. Parameters With Archived Guideline Values

Chlordane (total isomers)
Dichlorodiphenyltrichloroethane + metabolites
Endrin
Heptachlor + heptachlor epoxide
Lignin
Lindane
Methyl-parathion
Mirex
Pesticides (total)
Phenols (total)
Phthalic acid esters
Polychlorinated biphenyls (PCBs)
Polycyclic aromatic hydrocarbons (PAHs) (excluding benzo[a]pyrene)
Resin acids
Tannin
Temephos
Total organic carbon
Toxaphene
Triallate
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP)

10. Appendix B: Information Letter for Interview Research

SCHOOL OF
PUBLIC HEALTH
UNIVERSITY OF ALBERTA

Environmental Health Sciences
Department of Public Health Sciences

10-102 Clinical Sciences Building Tel: 780.492.1673
Edmonton, Alberta, Canada T6G 2G3 Fax: 780.492.7800

20 March 2007

Dear Participant:

Re: Information Letter for Interview Research

Research Project Title: The Role and Effectiveness of Drinking Water Quality Guidelines as a Measure for Managing Public Health Risks

Principal Investigator(s):	Leanne Bach (Varkonyi), Graduate Student Steve Hrudey, Supervisor

Background: Risk assessment plays a key role in drinking water guideline development throughout the world. In Canada, The Water Quality and Health Bureau (WQHB) of Health Canada is responsible for developing and recommending numerical drinking water quality guidelines based on risk management concepts. The guidelines developed by WQHB are intended to protect the health of all Canadians. The implementation of numerical drinking water quality guidelines has made risk management decision making easier for public health professionals by allowing the comparison of drinking water quality monitoring results to guideline values. The result of this comparison, at least in theory (*i.e.*, whether there is an exceedance of a guideline value or not) determines if the presence of a chemical in drinking water at the reported concentration constitutes a public health risk.

Purpose: You are being asked to participate in a research study to evaluate the role and effectiveness of drinking water quality guidelines as a measure for managing public health risks in Canada.

Procedures: Your contribution to the research will take the form of an in-person interview that is expected to be approximately one hour in duration. The interview will be conducted in a private setting (*i.e.*, your office or other, agreed upon private location) and will include:

- a combination of standardized, open-ended questions and closed, fixed-response questions that will primarily focus on collecting information on knowledge and opinions pertaining to the subject matter; and
- the possible collection of an audio recording of the interview to ensure the consistent recollection and transcription of responses.

You will be free to shut off the tape recorder at any time throughout the duration of the interview. Any audio recordings will be kept secure and stored by the researchers for a minimum of seven years in the University offices of the Department of Public Health - Environmental Health Sciences. Audio Recordings may be destroyed at any time following the minimum retention period. All information provided, excluding names and any identifying details will be retained and used in the research. The written work may include quotations from the interviews, but individuals will not be named and identifying details will not be used. The findings will be published.

Possible Benefits: It is not anticipated that any direct personal benefits will be realized by individual participants. However, insights gained from this investigation may reveal possible improvements in the guidance provided with the current drinking water guidelines to indicate how these may be used most effectively for achieving their intended aim, to protect the health of all Canadians

Possible Risks: No risks are anticipated from this study.

Confidentiality: Personal records relating to this study will be kept confidential. Information gathered during the course of each interview will be stored with precautions appropriate to the sensitivity of the data. You will be assigned an identification number and any research data collected about you during this study will not identify you by name (or other identifying details), only by your assigned identification number. A list cross-referencing participant names and identification numbers will be kept strictly confidential and stored separately from the collected data. Only those individuals involved in the research study will have access to audio recordings, corresponding transcriptions and/or written notes. Audio recordings will be destroyed in an appropriate manner following the completion of the study.

Voluntary Participation: If, at any point during the course of the research project, you wish to withdraw from the study, we will respect your decision immediately.

Contact Names and Telephone Numbers: If you have concerns about your rights as a study participant, you may contact the Chair of the Department of Public Health Sciences, Dr. Duncan Saunders, Phone: (780) 492-6814, Fax: (780) 492-0364, E-mail: Duncan.Saunders@ualberta.ca

Please contact any of the individuals identified below if you have any questions or concerns:

Name	**Title**	**Telephone Number**
Leanne Bach (Varkonyi)	Graduate Student	(780) 887-0871
Steve Hrudey	Supervisor, FRSC, PhD, DSc(Eng), PEng Associate Dean (Academic), School of Public Health Professor of Environmental Health Sciences	(780) 492-6807

Sincerely,

Leanne Bach (Varkonyi)
Graduate Student
University of Alberta – School of Public Health

11. Appendix C: Interview Consent Form

SCHOOL OF
PUBLIC HEALTH
UNIVERSITY OF ALBERTA

Environmental Health Sciences
Department of Public Health Sciences

10-102 Clinical Sciences Building Tel: 780.492.1673
Edmonton, Alberta, Canada T6G 2G3 Fax: 780.492.7800

Interview Consent Form

Part 1 (to be completed by the Principal Investigator):

Title of Project: An Evaluation of the Role and Effectiveness of Drinking Water Quality Guidelines as a Measure for Managing Public Health Risks

Principal Investigator(s):	Phone Number(s):
Leanne Bach (Varkonyi), Graduate Student	(780) 887-0871
Steve Hrudey, Supervisor	(780) 492-6807

Part 2 (to be completed by the research subject):

	Yes	No
Do you understand that you have been asked to be in a research study?	☐	☐
Have you read and received a copy of the attached Information Sheet?	☐	☐
Do you understand the benefits and risks involved in taking part in this research study?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Do you understand that you are free to withdraw from the study at any time without having to give a reason?	☐	☐
Has the issue of confidentiality been explained to you?	☐	☐
Do you understand who will have access to study records, including personally identifiable information?	☐	☐
Do you agree to the collection of audio recording of the interview to ensure the consistent recollection and transcription of responses?	☐	☐

Who explained this study to you? ______________________________

I agree to take part in this study: YES ☐ NO ☐

Signature of Research Participant: ______________________________

Printed Name of Research Participant: ____________________ Date: __________

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

Signature of Investigator or Designee: ____________________ Date: __________

12. Appendix D: Interview Questionnaire

Interview Questionnaire

<table>
<tr><th colspan="4">Section A: Background</th></tr>
<tr><td colspan="4">A1. Does your current position require you to apply the *"Guidelines for Canadian Drinking Water Quality"* prepared by Health Canada, to risk management decision making?</td></tr>
<tr><td></td><td>Yes</td><td></td><td>No</td></tr>
<tr><td colspan="4">A2. How long have you held a position that requires you to apply the *"Guidelines for Canadian Drinking Water Quality"* to manage public health risks from drinking water? How long have you been in your current position? Do you have any other relevant experience relating to the management of public health risks from drinking water?</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">A3. Typically, how do you use the *"Guidelines for Canadian Drinking Water Quality"* in your work? How often do you refer to the numerical guideline values?</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">A4. Throughout the course of your career have you had to take action (*i.e.,* issue a water usage advisory) due to the presence of a contaminant (physical, chemical, radiological, and/or microbial) in drinking water at concentrations exceeding water quality guideline values? What did this action entail?</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Section B: Guideline Development Knowledge
B1. How knowledgeable are you with the process used to establish the *Guidelines for Canadian Drinking Water Quality*? How would you rate your knowledge? (1-do not know what the process is to 5-know and understand the process extremely well)
B2. Are you familiar with the supporting technical documents created by Health Canada for established guideline values? How would you rate your familiarity with the supporting technical documents? (1-never heard of them to 5-know and understand the contents very well)
B3. For the practical application of guideline values, how useful are the supporting technical documents or any other documents published by Health Canada (list any identified)? (1-I have never looked at them to 5- extremely useful, I refer to them almost every time during the application of the guideline values).
B4. What are the major sources of uncertainty in numerical guideline values for chemicals in drinking water?
B5. How is uncertainty pertaining to expected health effects addressed in the *"Guidelines for Canadian Drinking Water Quality"?*
B6. The following are examples of uncertainty factors that have been used in Health Canada risk assessments to derive numerical guidelines: Lead: UF < 2 TCE: UF = 100 Antimony: UF = 300 THM (chloroform): UF = 2100

Section B: Guideline Development Knowledge

What do these UFs tell us about the corresponding guideline values?

B7. According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a carcinogen in drinking water may cause cancer in humans?

f) zero
g) at the guideline value
h) unknown exactly, but expected to be at a concentration significantly higher than the guideline value
i) any concentration
j) do not know

B8. According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a non-carcinogen in drinking water may cause an adverse health effect in humans?

f) zero
g) at the guideline value
h) unknown exactly, but expected to be at a concentration significantly higher than the guideline value
i) any concentration
j) do not know

Section C: Risk Management

C1. How would you define “safe drinking water”?

C2. Traditionally, drinking water suppliers and regulators have relied heavily on compliance monitoring to ensure the safety of drinking water. What are the practical and conceptual limitations of compliance monitoring for assuring safe drinking water?

C3. Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion? How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs*. chemical parameters?

C4. Health Canada has developed numerical, health-based, drinking water quality guideline values for numerous (approximately 64) chemical parameters . Do you think that each of these chemical parameters all warrant the same level of attention? If yes, why? If no, what should the level of attention depend on? Do you think that the *Guidelines for Canadian Drinking Water Quality* are presented in a way that adequately reflects the relative levels of attention that are warranted?

C5. For how many of the parameters included in the *Guidelines for Canadian Drinking Water Quality*, do you think there is established evidence of causing human health impacts via drinking water exposure?

C6. When a water use advisory is issued as a result of a chemical in drinking water at concentrations exceeding the guideline value, secondary risks may be posed. Of the following secondary risks, which ones do you think have the potential to significantly impact public health? Rate the significance on a scale of 1-5 (1=no significance to 5 =

<table>
<tr><th colspan="2">Section C: Risk Management</th></tr>
<tr><td colspan="2">very significant). In your opinion, are there any other secondary risks to consider?</td></tr>
<tr><td></td><td>Inadequate personal hygiene (not bathing, not washing hands)</td></tr>
<tr><td></td><td>Inability to cook nutritious meals</td></tr>
<tr><td></td><td>Reduced water intake</td></tr>
<tr><td></td><td>Stress/fear and decreased confidence in water supply</td></tr>
<tr><td></td><td>Re-allocation of limited personal economic resources to purchase alternative, more expensive sources of water</td></tr>
<tr><td></td><td>Not washing produce (fruit/vegetables) prior to eating</td></tr>
<tr><td></td><td>Not cleaning home/office</td></tr>
<tr><td></td><td>Personal injury (e.g. scalding)</td></tr>
<tr><td></td><td>Other ______________________________</td></tr>
<tr><td></td><td>Other ______________________________</td></tr>
<tr><td colspan="2">Comments?</td></tr>
<tr><td colspan="2">C7. How do water advisories impact the public's confidence in the water supply? Is this relevant to protecting the health of the public?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">C8. Health Canada's mandate and expertise lies in protecting the health of all Canadians by developing the <i>Guidelines for Canadian Drinking Water Quality.</i> How effective are the current guidelines at protecting the health of Canadians within your jurisdiction? How specifically do you know this? What evidence or observations demonstrate this?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">C9. Do you think that monitoring to indicate that physical, chemical, microbial, and radiological parameters in drinking water below (within) the current <i>Guidelines for Canadian Drinking Water Quality</i> assures safe drinking water?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">C10. Relative to other measures included in a multi-barrier approach to safe drinking water, how important are the specific guideline numbers (MACs) for ensuring safe drinking water?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">C11. How much could chemical concentrations exceed a guideline before you would expect to see adverse health effects in the consuming population?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">C12. How do you believe the public expects you to implement drinking water guidelines?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">C13. Do guideline values as currently presented to the public adequately portray the expected dose-response relationship and corresponding uncertainties?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">C14. If you observe an exceedance of a guideline value, what other types of evidence do you look at prior to taking action?</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">C16. With the development of more guideline values and/or the lowering of current guideline values, what type of responses would you expect to see within the population?</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Section D: Comments and Recommendations
D1. In addition to what is already being done, do you have other expectations of Health Canada when it comes to establishing and implementing the *Guidelines for Canadian Drinking Water Quality?*
D2. Are there changes you would suggest regarding how to apply (e.g shut down a plant based on a single exceedance of any MAC) chemical guideline values to ensure that water quality guideline values provide the most benefit for all and achieve their intended aim?
D3. Do you feel that you have received adequate guidance on the application of water quality guideline values? Who has/should provide this guidance? In what format was/should this guidance be provided? Formal (classroom, web-based) training, guidance documents, communication?
D4. What can Health Canada do or provide to ensure the consistent and reasonable application of guideline values?
D5. Additional Comments:

13. Appendix E: Summary of Interview Responses

Table E1. Summary of Responses for Question A1

Does your current position require you to apply the *Guidelines for Canadian Drinking Water Quality* prepared by Health Canada to risk management decision making?	
Response	Comment
Yes	None
Yes	None
Yes	None
Yes	None
Yes	Not directly in the field. However, in the course of the work that I do, it's an integral part of the development of policies and procedures that we set up for the province
Yes	As a reference, not for enforcement.
Yes	None
Yes	None
Yes	Not a lot. Aware of the guidelines but not used constantly.
Yes	None
Yes	My focus is in approving physical water works and in doing so we do make reference to the GCDWQ.
Yes	However, not as technical in current position.
Yes	None
Yes	None
Yes	None
No	I am involved in the development of the guidelines, not their application.
Yes	None
Yes	But I also look to other standards.
Yes	None
Yes	None
Yes	None
Yes	None
Yes	None
Yes	None
Yes	None
Yes	None
Yes	Although, I have discretion in their application.
Yes	None

Table E2. Summary of Responses for Question A2

What is your current position?	How long have you held your current position (years)?	How many years total relevant experience do you have?
Environmental Health Advisor - Water Consultant	4	11
Environmental Health Advisor - Water Consultant	4	7.5
Health Risk Assessment Specialist	10	17
Project Coordinator	0.4	8
Project Team Leader - Drinking Water	0.4	10
Environmental Health Consultant	3	5
Manager of Environmental Health	10	15
Communicable Disease Educator/Public Health Inspector	4	10
Public Health Inspection Manager	9.5	27
Senior Drinking Water Officer	4	15
Public Health Engineer	3	15
Assistant Director of Health Protection	5	20
Assistant Director of Health Protection - Drinking Water	3.5	12
Associate Director of Environmental Public Health	15	15
Director, Environmental Public Health	10	35
Drinking Water Specialist	13	37
Supervisor - Drinking Water and Emergency Preparedness	17	23
Drinking Water Specialist	6	18
Public Health Inspector - Drinking Water Program	4	15
Public Health Inspector - Drinking Water Program	1.5	1.5
Water - Healthy Environments	6	14
Supervisor - Environmental Health Assessment Research	6	10
Executive Officer/Public Health Inspector	4	5
Functional Program Specialist - Drinking Water	4	25
Senior Drinking Water Officer	3.5	15
Director of Operations for Health Protection	17	31
Drinking Water Officer, Specialist	4	10
Senior Drinking Water Officer	5	29

Table E3. Summary of Responses for Question A3

Typically, how do you use the *Guidelines for Canadian Drinking Water Quality* in your work?	How often do you refer to the numerical guideline values?
As reference material. They provide us with some ability to interpret the reasons for the guidelines. Because when we are applying a guideline and people wonder why we are applying the guideline we have to explain the purpose and the end result we're trying to achieve by applying them.	On average, daily but between daily and weekly. Some weeks, five times a day. And other weeks, I could go a whole week without having to talk to somebody about them.
To compare the results of monitoring, as a place to start really. For some of the guidelines, it's pretty straightforward, like bacteriological for instance. For the chemical, it's less straightforward but it still gives you a place to start and it depends on the substance.	Probably weekly.
Often I am given data to review and I am asked for my advice. We do not issue water advisories we only provide advice when requested to do so.	Not too often. In the last year I have only been consulted 3 times.
Predominantly for a couple of things: 1) as a provincial representative, developing response protocols for a variety of regional health authorities; and 2) used routinely in some of the health surveillance projects that we do.	That would be hard because it depends if it's an action request or a project. So I probably look at them once or twice a week. Sometimes more; sometimes way less. It's really too variable. It depends on what comes down the pipe.
My work is primarily focused on policy so whenever decisions are made around drinking water quality and how those guidelines are being applied, [I refer to the guidelines].	On-going.
We don't actually enforce any of the regulations here. So I wouldn't have to be reviewing any reports or referencing what the guidelines are stating. It would be used more for a reference document for us and then we'd be referring others towards it. For example, somebody would phone and say there's a situation in my water. And if we can't refer them to the regional health authority then we might also give them other references like the Canadian drinking water guidelines that they can refer to.	As needed.
I use them as a resource or reference document to provide water quality advice to the province and regional health authorities.	-

Table E3. Summary of Responses for Question A3

Typically, how do you use the *Guidelines for Canadian Drinking Water Quality* in your work?	How often do you refer to the numerical guideline values?
Work with province (Environment) to issue advisories, as required. They are the standard applied to public water supplies.	Depends, probably once per month. Maybe more or less frequently depending on the time of year,
I refer to the guidelines when there is a known problem with a small system (park, campground, *etc*.). I can think of 1 occasion where a community had high selenium levels and we referenced the guidelines and made some recommendations to the municipality to provide filters to remove the selenium.	A couple of times per year. I am aware of the guidelines, they are on the shelf but it is not something that I use constantly.
In the absence of any numerical guide, we use the CDWQG as a benchmark for what is safe to consume. Typically, may deal with someone who will phone in and want to know what to do with their water or dealing with a large municipality and they have all been written letters telling them to have a plan in place to meet the guidelines and applicable drinking water objectives. Another typical thing is people will come in and ask if their water is potable. We will look at chemical analysis and compare to the guidelines. The other thing is when people think that their water systems aren't improving the water quality. So we will use them as the federal benchmark.	Pretty much hourly.
Used for guidance for treatment standards and for parameter values. Certainly don't apply the tables of parameters as much as the supporting documents.	Numerical guidelines, a few months a year and the technical guidance documents maybe every two weeks.
We get analyses and we compare that against the guideline and that is really your first cut at risk based decision making on what we are calling a national standard or benchmark. That is the main use. In more recent years we have really turned a lot more attention to the supporting documentation.	-
As a reference, for program and policy development.	Quite frequently.
As a reference point, not a black and white line. I do not like to enforce the MAC. The MAC is nothing more than a number to be used as a reference point for communication and action only.	Ongoing.
As a reference, first line of comparison.	Bacteriological more common.

Table E3. Summary of Responses for Question A3

Typically, how do you use the *Guidelines for Canadian Drinking Water Quality* in your work?	How often do you refer to the numerical guideline values?
My function is that of an advisor and policy developer, not a front person.	Not applicable.
Day to day used for contaminated water. The big one has to do with *E. coli* and coliforms. As well, just recently we went through turbidity in the GCDWQ to determine what we had to do.	Day to day.
As a tool for the review of chemical analysis. The labs use the guidelines. Will not necessarily accept the number.	On a daily basis.
Use them for regulated water systems. As a comparison tool every 3-5 years when we do full chemical analysis. Used on a case-by-case basis for private water complaints.	-
Used as a comparison for chemical analysis. Bacteriological guidelines are very prescriptive.	-
As needed, guidance.	As needed.
As needed, guidance.	Rarely, as needed.
Most often to compare water quality results to guideline values.	Not very often, monthly.
As back-up documentation.	Not on a regular basis.
Historically doing health inspection work, water analyses results would be compared to the guidelines for the purposes of providing private individuals with information on their water quality. Also for subdivision approval work we will also comment on water source quality compared to the guidelines. Just recently have gotten out of providing comments on individual water supplies and leaving it up to the well owner. In my present job we use the guidelines to help us develop policy and practices. For example, we have used the guideline discussion on turbidity to develop our turbidity indication and notification campaign.	Almost daily.
In a number of ways: 1) to interpret laboratory results (comparison to standard); 2) as a planning tool; 3) used broadly for water management issues - to guide discussion.	Constantly.
A reference and resource. We use them as a guideline, not a regulation. Not a mandatory item.	I look them up as a reference probably monthly.
I think they sort of guide us in all of our decisions on a daily basis. We use them quite regularly for bacteriological, increasingly for turbidity. For chemical analysis rather irregular, review for water source.	Use quite regularly, almost on a daily basis.

Table E4. Summary of Responses for Question A4

Throughout the course of your career have you had to take action due to the presence of a contaminant in drinking water at concentrations exceeding water quality guideline values? What did this action entail?
Yes, from private residences to municipalities at least 30-50 times over the span of about 5 years. Mainly boil water advisories, no radiological or viral, iron, manganese, THMs.
About 20-30 times. Most but not all of them were microbiological. The ones that weren't bacteriological, we issued them as part of the precautionary approach. For others, just thinking of THM's, we issued advisories. It was based on exceedance of the guidelines or for bromodichloromethane And we're in the process now of arranging to issue some; I don't know if I'd call them advisories. They're more just public notifications based on exceedances of the guidelines. In public notifications too I mean, with respect to fluoride I would advise a communal drinking water system, or a non-licensed water system that they're exceeding fluoride. But, again, it's less than an informed advisory because I think that an advisory kind of carries certain connotations with it in terms of alarm. So, something like fluoride would be more or less public notification. Yeah, along the same lines it is disclosure to the public. Nitrates is another one too and sodium. THMs - BDCM, fluoride, nitrates, sodium
Do not take action in my role, only offer guidance when requested by the health regions. Have had to deal with Arsenic concentrations over the guideline value.
Yes, about 7 at the community scale and many private water supplies. Three chemical issues paint thinner spilled into reservoir, sulfate and acetone.
Many years ago
Not applicable in my position but have had to recommend action in the past for bacteriological exceedances in private systems
For chemicals, arsenic and hydrocarbon contamination - both cases "do not consume"
Bacteriological positives for small systems, *E. coli* and total coliform a few a year; others include nitrates, uranium and arsenic
Issue boil water advisories for bacteriological problems about once per year; had to deal with a selenium issue in one community where reverse osmosis was recommended - no other chemicals.
Yes, boil water notice or order for bacteriological exceedances - almost 1 per week; maybe have taken action based on chemical exceedance about 5 times; arsenic, uranium; have restricted water use due to low flow
In current role - no. As manager/operator, many times most often due to failure of equipment. Primary concern microbiological, greater risk than chemicals. Microbiological issue - weekly; chemicals years. Have never taken action based on chemical exceedance but if you aren't looking for one, you won't find a problem.
Yes, in the last 4 years ~600 water systems and 10% are on advisories which we are working to resolve. Three tiers of action: 1. Water Quality Advisory; 2. Boil Water Notice; 3. Do not consume order
Action due to issues with bacteriological contamination issues.

Table E4. Summary of Responses for Question A4

Throughout the course of your career have you had to take action due to the presence of a contaminant in drinking water at concentrations exceeding water quality guideline values? What did this action entail?
No boil water advisories. Most important is to know what water normally looks like it is dangerous to have people taking action only when there is an exceedance but doing nothing if there is no exceedance. Have seen cases where bacteriological parameters exceed guideline value.
Boil water advisories, chemicals, need to keep in mind risk tradeoffs when changing treatment system.
Function is that of an advisor - never front line person.
Just turbidity.
Only microbiological; some problems with arsenic but action has only been "educational". Guideline is 10 ug/L due to economic considerations but health based evidence indicates that the number should be 0.2 ug/L
Microbiological - 99% of advisories; arsenic and nitrate levels have been issues
Yes, boil water advisories, arsenic and nitrates
Yes, no major ones, isolated, local drinking water advisories; one chemical issue with ethylene glycol.
Yes, no major ones, isolated, local drinking water advisories; one chemical issue with ethylene glycol.
Had 1 situation dealing with a chemical in drinking water that resulted in a no consumption order - greenhouse fertilizer entered water distribution system.
Yes, microcystin; haven't taken any action on DBPs as we are trying to collect more data; no issues with arsenic in the region. But we do less chemical sampling than microbiological. We need to improve the chemical suite to be more useful. Microbial focus.
Have dealt with microbial and turbidity issues, chemicals from a spill and arsenic, uranium, manganese, antimony - when we get a parameter say Arsenic or Antimony that comes in above the guidelines but we are still talking small amounts (naturally occurring) we would use a much more comprehensive risk assessment process. There is breathing space because most chemical guideline values are based on lifetime exposure. In most instances are not dealing with an acute hazard.
Yes, bulk of advisory work is microbiological. Used for chemical issues: fluoride, arsenic, uranium, lead, sulphates. DBPs - some study work has been done but there is no evidence to support the idea that there is a problem.
Most of our action has been related to biological requirements. We have given lots of orders and enforcement action in regards to meeting the disinfection requirements. We have taken action in regards to chemicals. For chemical/physical parameters, largely focused on regionally a few parameters of interest. Disinfection byproducts or THMs are what we are looking for. The other ones it seems that we're interested in primarily are arsenic, because we have elevated arsenic in some areas that is a big problem for us. I would say turbidity is another issue we are dealing with. Those are probably the top few chemical/physical parameters we are having trouble with.

Table E4. Summary of Responses for Question A4

Throughout the course of your career have you had to take action due to the presence of a contaminant in drinking water at concentrations exceeding water quality guideline values? What did this action entail?
Yes, majority are microbiological. Fuel spills, fluoride, hardness, THMs, uranium, arsenic.

Table E5. Summary of Responses for Question B1

How knowledgeable are you with the process used to establish the *Guidelines for Canadian Drinking Water Quality*?	
Rating	**Comment**
4	I believe I know the process enough to say I am a four out of five - I am not saying I am correct.
4	derivation
3	I would say the middle. I know what they are doing.
5	Actively involved
3.5	I am getting more and more knowledge all the time.
2	-
-	Some knowledge of microbial
3	General idea.
1	Not looked
2	Know how to use supporting documents understand review and logistics
1	I know they exist but I have not given them much thought
3	2 ways of setting MACs and AOs: 1. toxicology and 2. technology
2.5	-
4	-
3	Mix of science, health and the environment; very wide umbrella - good product
-	Not a toxicologist but I am very knowledgeable.
2	Not that knowledgeable
4	-
1.5	Vague idea
3	Literature review and science to determine TDI
2	Not too familiar
3	Similar to how other guideline values are set using risk assessment
1	Not very knowledgeable - inlvolves literature review and testing; MHO would be consulted
1	I rely on the process being good
3	I know that they survey the research and they bring together their expertise and available information and come up with essentially their best guess. I understand that some parameters are based on what available technology can reduce it to. The more information that is available, the better decision Health Canada can make and the more comfort we have basing our decisions on them. In areas where there are knowledge and information gaps we take a more conservative approach.
4.5	I think I am fairly knowledgeable with the Federal Provincial-Terrotorial Committee on Drinking Water. They develop the background material and the documents that support the guidelines.
4	I am reasonably comfortable with it.
4	-

Table E6. Summary of Responses for Question B2

How would you rate your familiarity with the supporting technical documents created by Health Canada for established guideline values?

Rating	Comment
3.5	For bacteriological and turbidity a 4 but for the chemical stuff a 3.
5	I know that they're there and I read through a lot of them a lot of the time
3	I go through them carefully but I only look at a few chemicals
4	Don't know total risk assessment communication, perception
3	I understand their intent and I have a sense of what goes into them
1	-
2.5	More familiar with microbial guidelines
	Varies by parameter
1.5	-
1 to 5	Some 5 - turbidity, parasites, uranium, and others a 1
3	Familiar with the documents but not familiar with how the numbers are established/revised
3	Know where to find them, refer to some of them and pull the relevant information out. Knowledge varies based on experience in dealing with parameter
1 to 5	Turbidity 5; chemicals 1
range	Variable - only review applicable ones
range	-
-	Have reviewed 100s of them.
3.5	Only the few that pertain to issues in our region
depends	Depends on focus
variable	Will reference technical documents when needed
varies	Have not gone through all of them, use as a resource when needed, more familiar with arsenic, total coliforms, viruses, protozoa
varies	Only some
varies	Only some
1	Not very familiar, will have a look on the internet and if I have any questions will go digging for more information
2.5	I have used them and I am reasonably familiar with their contents
4	Know how to access and I understand
varies	Very familiar on a case-by-case basis (THMs, uranium, lead).
4	I am familiar with them, look on a monthly basis.
4	No comment

Table E7. Summary of Responses for Question B3

For the practical application of the guideline values, how useful are the supporting technical documents?	
Rating	**Comment**
4	Very. They're very useful. We refer to them all the time. They're what we use here in Canada when we're talking about water quality.
-	Very useful if up to date.
-	Lots of things are confusing and don't really help me. For example, the Arsenic document is okay but controversial. The documents are important and present major evidence. But sometimes numbers are changed for no reason and people wonder why.
3	Good starting point, don't accept as end all be all
-	Important background piece. I think sometimes the technical level is fairly high. I don't think that's a bad thing but I just don't think that people in the public can necessarily understand all of it.
1	-
3.5	First stop, also look at other sources.
4	Fairly useful, provides background information, practical implications on what to tell people, really not that great of a document - no intention to help.
2.5	Adequate to determine risk.
4	Quite useful.
4	Very useful. As a technical person I would like to see them expanded. Who is the intended audience? Health professionals and operators use them the most.
3.5	Help to explain how number was derived.
-	Better than nothing, good starting point to base risk management decisions on; appropriate; may not be the latest technology; have expressed specific concerns for turbidity.
5	Handy to have because can go through the process and understand. There is no advice on application of guidelines but it is implied.
4	1st read is good, paint a broad picture; unrealistic expectations
4	Reasonable documents; no key elements missing; not the best.
5	Very useful, people want explanations.
4	They are good, saves time because don't have to research. Varies by document.
4	Good resource, lots of technical information.
-	Very useful.
-	Very useful.
4	Quite in depth, useful, more questions on emerging contaminants, would be very useful if used more frequently.
3	Have not had a problem with them. The slight drawback is in knowing what the risk is.
4	I find them useful but some frustration points. As a regulator I want black and white answers and that is not the way the supporting documents work. At the end of the day the decision falls to us to make the best decision but there is an awful lot of uncertainty involved. We have to use our best judgment.

Table E7. Summary of Responses for Question B3

For the practical application of the guideline values, how useful are the supporting technical documents?	
Rating	**Comment**
4	They are useful and provide the evidence needed, used to support decisions. One concern is that economic considerations are brought into the standard.
5	I do find them extremely useful but I don't rely on them exclusively.
4	I think we do need to use and reference them quite a bit. I don't always find the answers to questions. I think they are a guideline, a technical resource. So I would use them to help in decision making processes and the application and discretion in how we are going to apply that. We would also look at other organizations (*i.e.*, USEPA and WHO) that establish guidelines.

Table E8. Summary of Responses for Questions B4

What are the major sources of uncertainty in numerical guideline values for chemicals in drinking water?
1) Risk Communication - There's not a lot of risk communication in the numerical guidelines. It's all well and good to [provide] a number and say risk magically happens at this point and it doesn't happen at this point. And then to explain what is risk; Is it a lifetime exposure risk? Is it an acute risk? That's always a challenge. 2) Extrapolation from animals to humans. 3) Different WHO standards versus Canadian standards versus EPA standards and inconsistency in application of guidelines across jurisdictions.
Lack of scientific literature; emerging issues; shifts in science and technology - they've got shifts depending on who's doing the research and what their findings are; inconclusive studies. It just comes down to the information that's available.
There is lots of uncertainty because we can never get good epidemiological data: lack of epidemiological studies; animal to human extrapolation; risk management (study interpretation and other changes to numbers that are not explained).
Volume of water consumed; weight; cancer risk calculations are based on animal studies and data extrapolation.
Not enough data, in some cases very little information is available to do the health risk assessment. A lot of confusion around cancer *vs.* non-cancer risk and the thinking behind it is mixed into a pot and there is not enough data to make decisions but we are being asked to make decisions anyway.
Never 100% sure because you can't test humans so safety factors are applied to account for data extrapolation from animals to humans; limited information at present time; judgment calls and intuition.
Don't have direct human health data; are we using an appropriate study; lack of information; animal to human data extrapolation.
Animal studies; data extrapolation; defining the average human; limitations with respect to today's knowledge
No idea.
Changing lifestyles so [the public] does not consume water from a given water source on a regular basis. I am not quite sure what the criteria is based on but hypothetically if it is based on an adult consuming 8 glasses of that water for 20 years, that is never going to happen. Additional sources of exposure. For example, the public is concerned with sodium but they do not realize that there are much more significant sources of sodium in their diet. Others but not sure what they are.
It boils down to scientific evidence; where do you strike the line initially as benchmark. For some of them you have to take a leap of faith, move forward and learn more about it. I am an engineer not a health professional so I am not familiar with specific limitations with science.
Don't know, don't have a good enough understanding how numbers are set.
Is the study we are using representative of real exposures? A lot of the parameters that are looked at are based on assumptions regarding amount of water consumed and are a worst case scenario.
Science is not certain but the worst thing is personal opinions, values and politics. Those are the hardest to deal with. A good example is the problem we have now with BDCM. It is more of a policy issue than a science issue.
Using animal studies that are short duration, using high doses and using animals

Table E8. Summary of Responses for Questions B4

What are the major sources of uncertainty in numerical guideline values for chemicals in drinking water?
without gag reflexes, limited human data, data collection and interpretation, exposure assessment, toxicokinetics, different bodily responses
Well, there are two end-points – carcinogen and non-carcinogen. There are studies performed to derive the TDI based on the NOAEL or LOAEL and in that process there are a lot of uncertainties Interspecies studies, intraspecies studies, lifelong exposure, NOAEL *vs*. LOAEL and uncertainty can vary from 10 to 10,000 times. So in calculating the end-point for non-carcinogens there is a large amount of uncertainty. It depends on the study, how well was it done.
The person doing the readings or whatever you want to call it – human error is one thing we have to take into account. Equipment error, and that is the main two. Again, you take a sample and you determine what is in there – I see the room for error.
Is the guideline value specific to the real life exposure situation? Guideline is based on empirical research: lots of literature, weigh evidence, acute is well documented, 25- 30 years, additional exposure sources (arsenic exposure from food); rodent testing.
Not knowing a lot about the process, I guess it is just the reliability of the studies that they are pulling together and the severity of what they are measuring. There is NOAEL *vs*. LOAEL.
How humans are affected, data extrapolation, lack of data, adults *vs*. children *vs*. sensitive populations
Data extrapolation from animals to humans, epi studies - representation of vulnerability; exposure; transfer to humans; extrapolation within the population
Animal to humans, epidemiological studies - representation of vulnerability; exposure; adults *vs*. children *vs*. elderly
Not very familiar with this. Cross-species extrapolation/uncertainty; how sure are we of this value? Is it actually representative of health effect?
Don't know, I am not familiar with this - assume problems with methodology, validity of test results, *etc*.
There is an awful lot of uncertainty involved. There is more uncertainty with some parameters than others.
The uncertainty is not clear in any of the documentation – what is the safety factor, what are they building into it. Is it a factor of 10, is it a factor of 100. That is not clear in the documents. The interpretation at the public level is that you have 1 ppb as the standard and at 1.001 you will start experiencing health effects. That is not the intent. I think of the standard as that is the way the public interprets it. A clear interpretation is not made clear in the documents.
In terms of uncertainty and measurements of uncertainty it is not my strength. I think that probably the major differences would be when you move from animal studies to human health studies and then short term *vs*. long term exposures. The unknown about the toxicology. If I am uncertain about a level of risk or uncertainty, I will consult with someone else on that. If we have a parameter that is at or near the guideline and there is a level of uncertainty there, and we are wondering whether or not it is an unacceptable risk, I would usually check with our MHO or get a medical opinion on it.

Table E8. Summary of Responses for Questions B4

What are the major sources of uncertainty in numerical guideline values for chemicals in drinking water?
I think it would be in the estimation of exposure and how you determine how much water people are consuming and how much risk they are exposing themselves to. I think there are lots of areas of uncertainty and I think some of them are in the designation that Health Canada uses in setting these things, I think there is sometimes a lack of research to clearly establish what the numerical value should be. So from my understanding there is a lot of debate in regards to how much levels of safety factors are applied to those numbers in setting the guidelines. I understand there is an awful lot of negotiation from what could be a numerical risk factor to what is practical reality that can be achieved. So I think there is a bit of balancing of those risks, those factors, that eventually come up to a compromise to what that numerical value should be. I think there is an awful lot of uncertainty throughout the whole process.

Table E9. Summary of Responses for Questions B5

How is uncertainty pertaining to expected health effects addressed in the *Guidelines for Canadian Drinking Water Quality*?
The guidelines do a lot of quoting of academic studies but don't really help in putting it into a person's personal experience and [addressing] the uncertainty involved. It's the number in the executive summary or in the table that people look at or really care about.
It has to do with their approach like their weight-of-evidence based approach to coming out with the guideline. And I'm not so certain if they factor uncertainty into the derivation. I can't really say I'm familiar with that. I know that an important part of risk assessment is to factor in the uncertainty principles.
Uncertainty factors are used. But for many sources of uncertainty you can not quantify by using a number. Uncertainty factors are subjective.
Well they use a standardized numbering factor. So it, it's typically seventy kilograms, 2L of water per day per kilogram and this standardizes exposure.
I would assume it is addressed through the fact that they use safety factors. So they say the risk is "x" so in order to make sure that really nothing does happen that will increase it by a factor of 10 fold or a 100 fold, *etc*..
I know they used to apply uncertainty factors but I don't know if that is still the case.
I don't know. I'll be honest, I really don't know but I assume they use some calculations.
No idea.
Numbers are only one part of a health risk assessment. The guidelines are not written into law so there is some discretionary decision making that allows us to take uncertainty into account. By not using them strictly and putting common sense with them we consider uncertainty.
I am not familiar with it and I can only assume that they have the frame of mind to error on the side of caution and have some contingency built in.
Don't know.
My understanding is that they look at the worst case scenario and take that into account.
The guideline technical documents outline how certain they are, how comfortable they are with the number and the safety factor built in.
Model generically and extrapolate 70 years - best guess scenario.
Apply uncertainty factor between 10 and 10,000 times in the derivation of the TDI.
Don't know - try to include.
It is not clear in the documents. I would like them to explain the number crunching clearly so you can follow through the calculations. The uncertainty factor should be stated or foot-noted and if there is a large uncertainty factor there should be additional information required to take action. The MACs with higher uncertainty value should be flagged – shouldn't just make a lower guideline value. People in our positions would like it put out there so we know what the uncertainty is. I suspect they leave it out because it may confuse an operator. People like numbers but we have to be very clear on what the values mean.

Table E9. Summary of Responses for Questions B5

How is uncertainty pertaining to expected health effects addressed in the *Guidelines for Canadian Drinking Water Quality*?
I assume that there is a certain weighting given to those uncertainties. The lower the weighting the more certain they are.
Lots of uncertainty so error on the side of caution, make IMACs; arsenic based on level of treatment
Evaluate the weight of evidence; uncertainty factors; judgment
Weight of evidence approach and data extrapolation; apply uncertainty factors using scientific judgment
Pick a number that is beyond safe or the number should be a lot lower.
Don't know.
I can understand where they are pointing out uncertainties and where the knowledge gaps are and where they are putting caution up. Even if I don't understand the math or fully understand the uncertainty factor, I get the general drift that there are guidelines out there. There is more uncertainty with some parameters than others. We have to use our best judgment in their application.
Clear interpretation is not in the documents.
The uncertainties from all of the sources are evaluated and if you have a 10-fold uncertainty it is because of a human/animal model. You would essentially multiply all of your sources of uncertainty together and come up with an overall uncertainty factor. So it can actually get quite large. Like a 3-order of magnitude uncertainty, depending on the evidence and of course the larger the uncertainty factor, the less certain you are with what you are talking about. So they usually use the precautionary principle in that case.
I think it is in setting the kind of risk factor or safety factor they want to put into it. From my understanding for different chemicals and for different problems that we have, there will be a different risk factor assignees with those numbers.

Table E10. Summary of Responses for Questions B6

What do uncertainty factors tell us about corresponding guideline values?
They definitely tell us there's a certain amount of uncertainty when coming to agreement on what the guideline value is and clearly, when you have a group of people from different academic or professional backgrounds interpreting it and trying to decide on what to do with that number, the derivation of a guideline appears to me to be a bit of a compromise usually. Just throwing out that there's an uncertainty factor doesn't help us too much when we're talking to the public. You can pick a government agency like environment and they might say {that although there is a significant] uncertainty factor that this is what the guideline is and we're going to adopt it as a regulation. Well then you're screwed. What do you do? It's a regulation and the guideline but realistically, when you have that big of an uncertainty factor what's the health risk? Very difficult. You know, you've got to fulfill a mandate based on precaution and precautionary principles.
Based on the agency and mandate, it's open to interpretation. With the health agencies, it puts them in the position of either choosing not to disclose water quality information to the public or ignoring the guidelines. So a higher uncertainty factor I think definitely requires more interpretation, more examination of the scientific literature and evidence that's available on behalf of the health agency that's applying the guideline and it's a real headache. It makes me nervous because I know how tricky it is to communicate risk especially when you've got an uncertainty factor of 1000 or higher.
It is very tricky. For example, careful review of the THM guidelines shows that the guideline value is based on a study in a rat where liver damage was observed. Therefore, there is lots of uncertainty. The bigger the uncertainty factor, the less confidence we have in the guideline value. If we have a long history of studying, we know what kind of levels can cause certain effects. But for THMs, there is little confidence because there is so much uncertainty. When there is low confidence, I tend to go through the guideline documents more thoroughly.
That they're predominantly recommendations. Basically they're a guideline to follow the recommendations. So if there's an exceedance of that guideline, a stakeholder or an approving agency understands that even if it's, you know, five over, you still are going to have a great deal of movability in terms of what the true health impact would be.
I'm going to assume that we know a lot more about the effects of lead on us than we do THM on us. I guess if people knew or understood the uncertainty factor, it might decrease their confidence in the guideline value. If you don't know it or don't understand it, it would probably do nothing to your confidence.
Don't know; numerical value is more of a guideline than anything. But in terms of an uncertainty factor of 300 *vs*. 500, I don't know what that means.
There is lots of uncertainty and extrapolation. If there is so much uncertainty, we should not establish a MAC. This is particularly true for THMs because disinfection is critical for protecting public health.
No idea.
The larger the uncertainty factor, the less certainty we have that there will be health effects at the numerical guideline value. Important to be aware of them but I have never used or seen them used - keep in mind at least 80% of issues with water are for biological hazards, not chemical.
I have never heard the term uncertainty factor until now. I tried to research the term

Table E10. Summary of Responses for Questions B6

What do uncertainty factors tell us about corresponding guideline values?
but could not find any information. Based on what you have described in your question, the higher the uncertainty value the more uncertain with respect to health effects and the frequency we observe them and maybe more research is required.
Doesn't say a lot - some numerical limits are more protective than others. How confident are we that we can apply this data to humans.
We tend to be more conservative with more uncertainty. Understanding uncertainty factors is one thing and what the implications are is another. Therefore there is a balance in looking at the uncertainty factor and the assSociated health risk. For example, even if there is high uncertainty, you may want to be conservative because the health risk is great. I think that they go hand in hand and it is important to take that into consideration in the guidelines. The challenge is that it is more of a grey area and the more information people have about uncertainty, the harder it is to make a decision but that is not saying they should not make a decision. THMs is a good example - are we more concerned because it is very prevalent or less concerned because there is so much uncertainty. Regardless, we have to make decisions based on the information we have.
A MAC is a reference point for action, even though you have a very high uncertainty factor, it becomes a communication tool. The margin of uncertainty does not make a difference, it becomes an action and communication point and discussion of the derivation process and uncertainty factors should help in risk management. For example, BDCM guideline is based on 30 minute bath. Therefore, can communicate this to the public and say you can reduce your risk by not taking a 30-minute bath daily, *etc*. In my opinion, there should not be a cut off where the uncertainty factor is too high and a MAC is not established.
The lower the uncertainty factor, the more we know. There should be a cut off where we don't establish a numerical guideline when the UF is too high.
Uncertainty factors up to 10,000, WHO and USEPA do the same thing. I am not the expert on that. I am not the toxicologist but my personal view is that the numerical value is just one of the things we should be looking at. We can question the number and the safety factors.
What it tells me is that when we are putting these numbers together we have to put in a safety factor because it is not an exact science so it tells me that we have to error on the side of safety.
There is not a lot of evidence or supporting hard data to lower the uncertainty factor. When the uncertainty factor is higher it tells me that through their analysis of information, they are uncertain. If there is too much uncertainty it should be stated and footnoted, at least. People in our positions need to be more informed regarding uncertainties. I suspect it is not in the document because it may confuse an operator. However, we have to clarify what we mean by these values.
The lower the uncertainty factor, the more certain they are and the greater the uncertainty factor the less certain they are - Important to be communicated when applying guideline values.
Not a lot of information on THMs - guess or best estimate
Just looking at the number, the lower the number the more certain we are and the more confident we are that the data we have is reflective of the reaction it is causing in the human body; a large uncertainty factor means we are not sure; a small uncertainty factor means life is much easier

Table E10. Summary of Responses for Questions B6

What do uncertainty factors tell us about corresponding guideline values?
The lower the uncertainty factor the more certain we are.
I am not very familiar with this. If there is a higher uncertainty factor a number that is beyond safe (or a lot lower) is picked. There is uncertainty due to cross-species extrapolation and they may not be sure of the value or if it is actually representative of health effects.
Well, again not being entirely familiar with the meaning of uncertainty factor, I would assume that this would mean that the result for chloroform is less reliable than the result for lead as far as human risk is concerned. So we would put less weight on the test result for lead. With THM UF of 2100, I would be looking at treatment process and sampling procedures and would rely less heavily on the test result. Whereas, if I had a result for lead with little uncertainty I would know exactly where I am at. That would be my assumption but it is an area where I need some education for sure.
I guess from a lay person's perspective, the bigger the number, the more uncertainty with the information that goes into the guideline. So it will be a harder time making a decision with the parameter that has a higher uncertainty factor.
With a lower uncertainty factor, can be very certain with respect to health outcomes. With a higher uncertainty factor, much harder to articulate health outcome. We are pointed in a general direction but we need better science to focus the values - pretty much a ball park. I think the issue comes out in trying to interpret a result and then taking that back to a constituent. We can be very certain when we see a certain level of lead that this is going to be the resulting health impact. With THMs it is not so certain and it is much harder to articulate to them exactly what they are going to experience as a health outcome from what they are seeing their lab results.
We are pretty certain about the toxicology of lead and the strength of the evidence is pretty well understood. Whereas, with THM in terms of chloroform, we have a large level of uncertainty. It suggests to me that we understand the toxicology of lead and the safe exposure limits attributed to it. Where we have only a general idea about the toxicology of THMs. The risk posed by arsenic at the guideline value is very different than the risk posed by lead at the guideline value. The respondent felt that the large level of uncertainty with respect to THMs may be attributed to the carcinogen effect and the fact that cancer can be caused from a wide range of sources. Trying to find out whether the cancer is attributed to exposure to chloroform or some other agent can be very difficult. Issue: THMs are not carcinogenic. Even if they were, in the case of carcinogens, the guideline value is determined with respect to the incremental lifetime risk posed by a substance's presence in water, and is not set with regard to an individual's total risk from all sources of exposure.
Well, I am not quite positive but looking at this the way I would look at it, with lead, we are pretty sure what the health effects are and there is pretty good research that went into it so we have a pretty good indication of what would be expected as far as health outcomes or health risks associated with it. As that number grows, I would expect that the research isn't really quite clear, we still don't know what the mechanism is, we understand there is an associated risk with this and we understand that there is a huge public outrage or uncertainty with these things so a lot of factors go into setting that number. So I would suspect that when the uncertainty factor goes up, to prove a direct causal relationship between the constituent and the health outcome is a little bit more uncertain.

Table E11. Summary of Responses for Questions B7 and B8

According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a carcinogen in drinking water may cause cancer in humans?		According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a non-carcinogen in drinking water may cause an adverse health effect in humans?	
Answer	Comment	Answer	Comment
e	I've never even bothered to try and look up the methodology cause I don't have time for that.	e	I've never even bothered to try and look up the methodology cause I don't have time for that.
d		c	There's a lot of confusion around the cancer risk *vs.* the non cancer risk and the guideline isn't that clear about. The application behind it is kind of mixed into a box and you can't tell which is which and for the one time exceedance of a long term risk or short term risk.
d	-	c	-
e	-	e	-
c	-	c	-
c	Significant safety factor; MAC = 10, concentration of 12 not a severe health effect, for example.	c	Same as for carcinogen.
d	No safe level	c	-
c	-	c	-
c	Don't know for sure	b	Assumed. Arsenic for example should be ALARA; the numerical guideline should not be a safe threshold
e	-	e	-
b	Over a lifetime	b	Over a specified length of time and level of exposure
c	-	-	Depends on what it is.
e	Don't know 10-5 or 10-6.	c	Depends on the chemical.
c	-	c	-
c	-	c	-
e	I am thinking of all of them, it could be right on for one but no assumptions for another.	e	For iron, for example it is based on aesthetics. Just looking at health effects.
d	-	c	-
d	-	c	-
e	-	e	-
c	-	c	Because my understanding is that there is public perceptions around carcinogens *vs.* other health impacts. I am hoping that it is the

Table E11. Summary of Responses for Questions B7 and B8

According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a carcinogen in drinking water may cause cancer in humans?		According to Health Canada Risk Assessment methodology, at what concentration is it assumed that exposure to a non-carcinogen in drinking water may cause an adverse health effect in humans?	
			same. You need the safety factor whether it is a carcinogen or other negative health impact.
c	As I understand it there are some parameters, like arsenic that are believed to pose a level of risk at the guideline level. We would make the guideline zero if we felt there was technology out there that could get the concentration low enough.	e	-
e	It can be, well partly c and partly e. Unless there is a direct causal relationship between a particular type of cancer and a certain concentration. Yes we know that if you are exposed to arsenic in certain ways you have a much higher risk of developing skin cancer from exposure. However, individuals respond differently and have different susceptibilities and tolerances to these sorts of things. We don't know. You may be at higher risk but even if you are at higher risk, you may not develop cancer. A little bit of c and a little bit of e. Yes we know there is some connection there. There are some that are very clear and others are as clear as mud.	e	My understanding is that the guideline numbers are not necessarily tied to human health outcomes. We know that we have x number of bladder cancers and we have empirical evidence to tie it to this much exposure of pesticides for example over this period of time. There is more to it than just the guideline exposure itself. It is how to interpret that, what is the health message that comes out if we have water that is above the guideline. A lot of this stuff we estimate based on interpretation and statistics of health outcomes in certain areas.
d	My understanding of carcinogens is that there is no safe threshold exposure level.	c	My understanding is that there is a wide safety factor.
c	-	c	Same, because of the variables, age, sex to the amount of exposure, can you guarantee drinking water for 70- years. Water quality fluctuates, *etc*.

Table E12. Summary of Responses for Question C1

How would you define safe drinking water?
Whatever the WHO says. I've only used this definition a few times - basically water you can drink over your life time, it doesn't add to your health risk or burden.
It's water that does not pose an unacceptable health risk. Safe drinking water is water that will not cause an unacceptable risk of water borne illness from either microbiological or chemical hazards. Someone could drink the water for their entire life time and not expect to see any adverse health impact as a result of drinking that water. The impact could be a result of a deficiency of something that should be in the water or something that's in excess that could cause harm. For example, there are some people that would say water should have a certain level of fluoride in it and if it's deficient of fluoride, then you could see some health impacts. Unacceptable versus acceptable risk, that's an entirely different set of questions.
WHO definition - water that will not cause people to get sick, but you never know exactly.
To me if it meets or is below the guidelines it is safe. So in terms of me, it doesn't have any total or fecal coliforms, in terms of the guideline it's below the recommended THM level or below the lead level or below the level of whatever contaminant we want to talk about in terms of a chemical.
Safe if bacteriological guidelines are met, the guidelines offer a good framework but many chemicals we don't monitor for.
Microbiologically and chemically safe if it meets the guidelines, is potable, there is source water protection in place and restricted access to system.
Our public health act says that we don't say "safe drinking water", we say "potable water". So, that means potable drinking water is safe for consumption. But it, it's more than that. In terms of a public water supply, safe drinking water to me means that the water is potable, that there's a multi-barrier approach that is applied here so that you have a source of water protection. You have attention being given towards treatment and distribution of the water and monitoring of the water quality. Plus I think there has to be a regulatory oversight of the operation. So I think all of that together to me, is safe drinking water. Just one sample result doesn't necessarily guarantee safe drinking water. It could be safe at the point in time but ongoing portability or safety is questionable.
For me, primarily bacteriological parameters. If no coliform, *E. coli*, and turbidity the water quality is at a safe level. Potable (hygienic, human consumption), chemicals undetected, water is safe if below guidelines.
Meets microbiological standards, acceptable major ion and bacteriological results according to applicable regulation. If it is a seasonal operation we only require that they collect one sample before they open in accordance with the regulation (microbiological parameters and major ions).
Not defined anywhere for us. Difficulty in defining because more knowledge makes it quite a complicated issue. In general, drinking water which has nothing in it that will cause ill health effects.
It is defined in the legislation in terms of surface water being disinfected. Groundwater is safe to drink if no microbiological contamination. For myself I would define it as meeting or exceeding (on the good side) the GCDWQ. Safe in my mind would also need to include consistency because surface water quality fluctuates and we have higher than normal variations.

Table E12. Summary of Responses for Question C1

How would you define safe drinking water?
The version that we work with is set within the Drinking Water Protection Act - safe to consume and suitable for domestic purposes without further treatment. Safe to consume means it meets guidelines for 1. Microbiological, 2. physical, 3. chemical and 4. radiological parameters. Focusing on the microbiology first. If it meets the guidelines it should be safe but may not be palatable.
How the Walkerton report defines it reasonable person who is knowledgeable feels it is safe. Not defined well, depends on the audience; suppliers use the term differently.
Water that is safe to use for domestic purposes for all life stages.
Safe for human consumption. Water that does not cause disease or ill effect but there are so many uncertainties and lots of gray areas.
Meeting the guideline is just one aspect of many - don't get sick from drinking the water.
Water that meets the GCDWQ. Safe to drink as long as the GCDWQ cover the entire population, also need to consider chlorine residual.
It is based on monitoring results for chemical and bacteriological analysis - a whole host of things. Safe drinking water is water that is sampled and shown to meet bacteriological water quality - first, chemistry is second. Also, safe drinking water is water that meets health concern targets; water produced by competent operators; system that is adequately maintained; no complaints; backflow protection and source water protection.
As a regulator water is safe if it meets the standards prescribed in the regulation so that the water is potable and safe to drink without further treatment. Unfortunately they don't define safe in the legislation so it is a discretionary decision that we have to make. That is where the GCDWQ come in – we use that as a reference point because in our regulations there is nothing specific to chemical parameters. Prescriptive chemical guidance was not included because of financial considerations for small utilities.
Looking at the regulations: 1. potability standard must be met; and 2. people drink the water and do not get sick.
Water treatment plant and associated infrastructure working effectively and striving to keep contaminant levels so low that they are unlikely to pose a health risk to the population. Nothing can ever be 100% safe.
Water that meets or exceeds the guideline values - keeping in mind, nothing is 100% safe as we are limited by current levels of science and technology when we define safe. For example, 5 years ago nobody was concerned about benzene. More difficult to define safe when considering new and emerging contaminants. For example, we don't know if the treatment plant can effectively remove personal care products and pharmaceuticals that have been identified in sewage and in surface water bodies.
Water that does not cause any long or short term adverse health effects.
Potable, free from microbial contamination, free from risk of contamination. Yes, water can still be safe if there is an exceedance of a guideline value. They need to have adequate protection of the water supply. For the levels of contaminants we refer to the GCDWQ and the field manual – so that is easy. If you are open to contamination, it doesn't matter if you meet the guidelines or not. You have to evaluate the openness to contamination as well.
Grapple with this definition - it can mean so many different things. It is water that meets the 4-3-2-1-0 treatment objective; multi-barrier approach in place; meeting

Table E12. Summary of Responses for Question C1

How would you define safe drinking water?
microbiological standard, meets the health-based objectives of the GCDWQ - no such thing as absolutely safe.
In [our province] there is a legal definition of potable water. It meets the microbiological standard and it is safe for domestic use. First part is very clear, it must meet the schedule in terms of bacterial contaminants. From a legal basis. The other stuff, is it safe to drink? Speaks to the idea of what are the physical and chemical issues with the water that are being defined specifically by the GCDWQ in terms of safe exposures and actual concentrations. For domestic use, this goes back to the guidelines around the aesthetic parameters. The term safe water is relatively broad. Even in that whole thing, what is not defined well is the presence or absence or exposure levels or concentrations for parasites. That sort of speaks to the absence of viable parasites and that is really hard to define in current science. Those kinds of things are very poor in terms of their reliability.
I would say safe drinking water is water that generally meets the intent of the guidelines in the first pace and in the second place, water that is produced in a manner that complies with the multi-barrier approach to water quality. You can't simply look at the end result of what you have in the jar. It is a matter of looking upstream at how the water came to be that way. So rather than looking exclusively at water analyses data you need to look at process control data as well and also source water quality, treatment/distribution system, operator experience and education, *etc*.
This is a real tough one. Part of the difficulty is in the word safe and I don't think we are ever going to be able to resolve that issue. When I think about drinking water, I prefer to think of it in terms of it is my expectation when I drink water out of that tap, I will not experience any adverse health outcomes. Some will just say just whatever the guidelines say but that is not a very good proclamation. I think there is an expectation that when we drink the water we are not going to experience any adverse health outcomes and I think that is probably the best way of looking at it. And that opens it up so you can look at all the various constituents in drinking water and it allows you to do a health risk assessment that water can't be perfect all the time but is it really going to cause me an adverse health effect, things like that.

Table E13. Summary of Responses for Question C2

What are the practical and conceptual limitations of compliance monitoring for assuring safe drinking water?
It's one sample taken at one time and a one time exceedance doesn't mean you're necessarily at higher risk and that's why we've tried to move away from compliance monitoring. Our perspective of compliance monitoring is limited. For example, a supplier saying "I've only got 99 ppb of THM's in my water so leave me alone, I haven't exceeded 100 ppb.". Compliance monitoring is only good for raising flags. There are people who will take their water samples from the best place in the system; not the worst. There have had to be a lot of changes in the sampling approach because people are realizing that if they take [the sample] right after they chlorinate [they won't get bacteria] so the sample result is only as good as the person taking it. Is it a trained person? Where did they take [the sample]? Why did they take it? You know, whole concept of valid monitoring and what's representative I think could be looked at. [The laboratory] never makes mistakes. We rely on the lab to have QA/QC and standards so they're not making errors. We don't want false positives. We especially don't want false negatives.
We think that when you talk about compliance monitoring it's exclusive. Like, to really ask for something outside of what's required, can be met with some resistance or some suspicion so it can set some limitations and hamper the process. It is just a snapshot in time. In a lot of cases, it's not really useful at all. The data is only as good as the water quality at the time the sample was taken. You have to assume there are going to be fluctuations and compliance monitoring doesn't really account for fluctuations. It makes some assumptions. You're telling people what they have to monitor for and it's based on a few assumptions that may not always be correct. If you suspect that a water supply gets its source from a high quality ground water well, then based on what we know about the supply, the engineering or just the fact that it's a deep ground water well, for instance you may only have to sample once for THMs every three years and that's a huge assumption. If you don't capture a certain substance of concern in the one sample, then that's an additional three years of exposure or potential exposure to something that might be there.
Not sure, there are many areas to introduce error: lab being used, QA/QC, need guideline values and monitoring but need to be reasonable about what it means.
Perception to the public in terms of what is safe and what is not and in terms of cost and what is practical for them to pay. Monitoring is only a snap shot in time. As well, depending on the size of the community, you're only testing one day of the week, yet on the other hand, you can't continue to monitor every day or every hour so that's a limitation. Does it make the water unsafe? No. If the practices are followed and you're following the operational guidelines, I don't think so. With respect to the actual data, where was the sample collected and are they choosing the right point? Commonly a lot of them report on a yearly basis so you only see a yearly average. They don't present the range although they may have exceeded the guidelines. Other considerations include - who is collecting the sample (maybe it's someone who is non-operational). When you look at that data, you have to assume that the sample was taken correctly and if it is not taken correctly then the quality of your data is questionable.
Sampling limitations. If the source is high quality groundwater, will only sample every three years - sampling frequency is not adequate.
Well, compliance monitoring makes it easier and having a number for comparison is

Table E13. Summary of Responses for Question C2

What are the practical and conceptual limitations of compliance monitoring for assuring safe drinking water?
easier for the regulator. There is more difficulty in having any leeway with how you can react toa problem of exceedance.
It is one snap shot in time and is not an indication of the quality of water at the source or the state of the distribution system. It doesn't give you an indication of the type of operation that is going on. It doesn't give you an indication of the knowledge level of the operator and so on.
Compliance monitoring is good but it is only a spot check. It only provides you with water quality results for 1 hour out of an entire year. It is not an on-going monitoring system, things can go wrong and the responsibility is on the operator to make sure they are sampling. You only sample a few times a year so there are limitations.
I don't know. I am not sure what the limitations are but whatever they are I think we tend to ignore them unfortunately because the requirements for compliance monitoring for public water supplies in the regulations, the maximum is once every three months - that is a long time between water samples. Larger systems have to submit more samples. For example, if it is a seasonal operation we only require that they collect one sample before they open to indicate bacteriological acceptability in accordance with the regulations (microbiological parameters and major ions).
Compliance monitoring to the Drinking Water Protection Act. This act has a lot of components that address source to tap protection and it covers a much broader aspect. You need to look at other barriers. Limitations of monitoring include: it is expensive, not practical (logistically and costs), one sample per year does not provide assurance, people are not monitoring daily. Biggest limitation is that you pick up an event after it has happened. We compare the numbers we get to the GCDWQ, where did sample come from, there is no chemical profile made up from a water source - nothing to say that a developer has submitted a sample,from a supply that he knows is good. The intent is good but it is easy to negate or scope or design water that will meet the guidelines if that is the only thing you are relying on. [Laboratory] testing methodology is not something we get into, we just assume testing has been done accurately.
Conceptual limitation - it is a reactive approach, need to move to a more proactive approach that includes monitoring for turbidity, chlorine analyzers, color and pH that ensures all of the water is going through some quality control process all of the time as opposed to relying on a reactive approach.. Contaminant may not be present at the sampling location, false positive issue, water samples are random and infrequent, statistical issues and it provides a false sense of security.
The historical way of just collecting a grab sample only tells you what is happening at that particular moment in time. Problems can be missed and sometimes only 1 sample per year is collected for remote, small systems and chemical analysis is even less frequent - maybe once every five years.
It depends on how close you can get to real-time monitoring. The limitations are between raw water and monitoring the treatment process until distribution and what you are able to monitor. Our ability to get accurate measurements is a concern. Identification of the right indicators, particularly for pathogens is a limitation. The lab methodology, having different labs and using different methods is a difficulty.
Compliance monitoring for microbial parameters is not random (for example, a sample is collected every Monday morning), you can't depend on the sampling results and it is useless in detecting waterborne outbreaks. Chemical monitoring results do not mean much. Although there is less fluctuation there are ways to sample to avoid peaks so it

Table E13. Summary of Responses for Question C2

What are the practical and conceptual limitations of compliance monitoring for assuring safe drinking water?
is more important to understand the system being sampled.
Main limitations are time and logistics of sampling.
For me the safety of water depends on bacteriological water quality. Compliance monitoring only represents one point in time. Don't know the quality of the water 5 minutes after sample is collected. Turn around time on sampling is a limitation because you don't get results for more than 24 hours. Bacteria is not evenly distributed in the water. Use on-line monitoring to get some continuous indication of water quality.
Probably equipment, the people doing the monitoring and collection. Any inherent possibility for error and then possibly, lack of knowledge where we may have overlooked something where there could be something in our water that we are not testing for. It is not so bad for us because we have a source that stays virtually the same and they are testing it. But for example you may have a well and your aquifer can become polluted. If they don't know what is happening – they won't check for it.
It goes back to the parameters and what they mean as a measuring stick (*i.e.*, arsenic 9.9 *vs*. 10). Other limitations include the possibility of sampling error, especially for bacteriological samples. Is there a new person or did you run the water long enough, is it a representative sample, what procedure is used? Chemistry really can't go wrong.
Limitations include: 1) grab samples; 2) sample frequency is not defined; 3) costs; 4) issues with sample collection; 5) interpretation of results (dissolved *vs*. total concentrations)
It is a grab sample that only represents one moment in time and is not an accurate reflection of water quality. There can be a change in the system post sampling. Proper sample collection, sample methodology and analytical techniques. Fairly confident with the laboratory results because labs are certified.
Sampling error and quality assurance.
Limited by current science and technology. Cost is a big limitation.
Sample limitations include: 1 point in time, not representative of the water in the entire system
The first thing that comes to mind with any compliance program is that it is a snapshot approach and it may not address process issues with how sampling is done. We have to take the full picture – having historical data is very important so we can identify a sampling error or spike that may not be affecting the entire system. How system flushing is being done. One of the issues that we have is a tendency to take samples in the same location time after time which only tells us that a portion of the line is good. They can have compliant results but miss hot spots, dead ends in system, *etc*. Wanting to get the test done and get it in can be a limitation. You may have had a bad result that has a perfectly legitimate reason but since it takes time to get the result action may have already been taken to resolve the issue.
Compliance monitoring is essentially aimed at bacteriological monitoring. Our compliance monitoring does not include routine sampling for many other parameters (*i.e.*, don't do chemical sampling on a routine basis). A full chemical sampling program would only be done on large systems once per year, maybe every three years for smaller systems and for very small systems we would never see a full analysis. If we have a system with a particular issue, we may require sampling specific to that. Other limitations include: error in methodology, sampling error, geographic challenges

Table E13. Summary of Responses for Question C2

What are the practical and conceptual limitations of compliance monitoring for assuring safe drinking water?
(we fairly frequently loose whole batches of samples because they don't get there in time - particularly for the small systems which may have only been taking one sample per month – that is a big gap in data). The biggest limitation with bacteriological monitoring is that it is after the fact – 3-5 days after sample collection we get a result.
Snapshot in time, The sampling methods are unreliable for parasites – the method is only about 20% accurate. You have a huge margin of error just in the protocol. In terms of your use of coliform as an indicator, it is questionable whether it is useful even if the number of samples is statistically valid. If we look for fecal coliform we will find it. The reality is that there are 300 species of *E. coli* and they can't speciate for everything and new species are being created. So there is all this uncertainty down the chain. Historic practice, for the most part, has served us pretty well. But logistically speaking, I am not sure it is reliable. From a public health point of view, when it comes to chemical parameters – the cost and turnaround is a limitation. A regular response a large package of drinking water for chemical parameters could take 3 months and standard cost is 600-1000 dollars. That is a barrier that I am not quite sure we can deal with. Making sure that we have access to high quality labs is a bit of an issue. Private labs are only audited on a periodic basis. So the quality control in the private lab becomes an issue in my mind.
The main issue is the issue of representative sampling and water quality. Sampling is not predictive of health risks. If you have a sample, it still doesn't tell you if the next gallon of water will be safe. So it is not predictive it is more of a snapshot that tells you what is happening when you took the sample. By long term monitoring you may be able to infer a trend but it is all historical, it does not tell you what may happen tomorrow. A change in source water quality, operator, process control failure, you name it, there are a whole variety of reasons why you may experience a change in water quality and your past monitoring will not lead you to expect that.
Water quality changes very quickly and rapidly and the majority of our systems are still absolutely untreated and that water quality can change from cup-full to cup-full. You have absolutely no idea what that water quality is going to be like. The other difficulty with monitoring is it is after the fact all of the time, especially when you are looking at microbiological testing, it is never real time, on-line monitoring. There are a lot of practical variables. Are the water operators trained and know what they are doing. Do they know how to recognize a disruption to the normal operational chain. Do they have proper procedures to correct the operations if something has gone wrong. Do they have various monitoring methods in place. Do they have storage reservoirs that are protected? Is the distribution system protected from cross connection control. The list can go on and on and on.

Table E14. Summary of Responses for Question C3

Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion?	How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs.* chemical parameters?
Microbial. Based on lots of quotes and books from people like Dr. Hrudey and the WHO that say your incidents related to microbial illnesses are much higher than the incidents of disease from chemical illnesses. Specific to our region - It's very difficult to tie illness to things as ubiquitous as drinking water unless you have outbreaks. People drink all day long everywhere they are and they get sick all the time. But what's the likelihood of the illness coming from the water versus undercooked chicken? That's very difficult unless you have an outbreak or a population based surveillance.	There's a greater acceptance of microbial as being a valid guideline. I think people are more afraid of microbial illness in the sector whether it's utilities or health or environment. It's the operators, the public health people and the environment people who have looked at the last 20 years and there's been a lot more outbreaks related to microbial issues and it's really hard to say that chemical issues are ranked up there with them. In my mind, they're not ranked in the same way. We don't see as many chemical exceedances. We don't see a lot of population based studies that look at chemical exceedances and tie them specifically to rates of disease. You know, given the relative importance. [The microbial guidelines] are not being revisited every year.
I think that microbial derived illness is more common than chemically induced illness with respect to water. You just hear about incidents of gastrointestinal illness. You hear estimates about how much of it is attributed to drinking water even though it can't be really demonstrated effectively. You think about aging and failing infrastructure and distribution systems and how that introduces contamination throughout the system…microbiobial contamination within the system. Just personally I think it's safe to assume that a significant amount of gastrointestinal illness in the community is water borne.	I guess there's a more significant urgency put on microbial situations where there's evidence of or suspicion of bacterial or microbial contamination. No, this is not reflected in the way they are presented. Microbial are definitely kind of set in stone and in terms of how, how we respond and, and how we use the guidelines to back up our decisions. Whereas with chemical, it depends on the substance but we might feel a lot more confident with the guideline and say that it backs us up. Or there are some cases where we might say yeah, there's a guideline but we're not even sure how useful it is at all for a chemical substance.
Microbial - In drinking water, chemicals are not very common. Based on my knowledge, microbial – 1000s years experience. If you are exposed you can get sick right away.	More emphasis on microbial guideline – lots of certainty and high confidence. We know it will cause illness right away.

Table E14. Summary of Responses for Question C3

Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion?	How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs.* chemical parameters?
Microbial. I come to this conclusion based on what I've seen in the field in that people don't always attribute that to water, it comes down to a water source that they're exposed to. Chemical incidents usually if they've been at large, everyone knows about it. And they don't drink the water. Whereas microbial, they can't necessarily see if it's there. If it's a small incident like the one with the paint thinner, the reservoir, well everyone knows about it and no one's drinking the water. Usually chemical, you can taste, smell, or see it. So that's a natural deterrent for people to stop drinking the water.	Based on public perception - chemicals have a higher priority because people freak out if they don't understand? Microbial still, although it's more important to me coming from health. I'm not worried from a health aspect as much about chemical impacts *vs.* microbial because microbial's acute and can be deadly. Chemical is chronic and is potentially deadly after 70 years of life with that. Microbial is a lot easier to understand.
Microbial - no records of chemical-related illness, so only see those that are reported.	-
Microbial - would see enteric disease reports.	More likely to react to microbial parameters than chemical parameters.
I say microbial only because you hear more about that. Yeah. I really don't know. Definitely we hear about the microbial illnesses. But I don't think we hear about the chemical related illnesses unless people are actually reporting to hospitals because of it. But if there's chronic exposure and there's those health effects that have been realized from that, then we; it's really hit and miss. If we had a cluster of cancers in any given area, we would do some research in regards to what we thought was a cause.	There is an emphasis on the microbial parameters.
Microbial related illness. *E. coli* and other pathogens cause illness and we see water-related cases. With respect to cancer or other chemical-related illnesses we can never pinpoint the cause to drinking water and the health effects are long term in nature. If someone has liver cancer, we don't know the cause.	95% of what we do day to day is related to microbiological parameters and the other 5% pertains to chemical or physical parameters like nitrate. Much greater focus on microbial parameters. There is limited analysis for chemical parameters in drinking water so we don't have information. We have to know about a contaminant scenario first and once we find one we shift our focus. Health Canada guidelines tend to emphasize

Table E14. Summary of Responses for Question C3

Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion?	How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs.* chemical parameters?
	chemicals. There is much less emphasis by HC on microbiological parameters but it is much simpler *vs.* chemicals which are very technical and more "grey".
Microbiological based on events like North Battleford, Walkerton. Don't hear much about chemical-related illness.	Much more emphasis on microbial.
I Don't know. The difficulty is that the microbiology ones are looked at as more acute. You can track microbiology results in more real time and you can track it back to the water source quite easily.	Most of the chemicals are a chronic hazard and nobody is looking at chronic health issues and the link to drinking water.
Microbial, it is what is reported in the media and there have been outbreaks. Don't see the evidence for chemical-related illness. It is what I observe.	In the guidelines, both are covered, there is no bias on one *vs.* the other in terms of promoting one over the other. When it comes to using the guidelines in the practical world , the emphasis is to rely on microbiological sampling because chemical sampling is done very infrequently (at the discretion of the water utility, one-time sampling measured in terms of years) *vs.* once a week for microbial sampling.
In our province, microbial based on personal experience and provincial health officer reports. That is not to say that there are not chemical events. Microbiological exposure can be associated with a disease outbreak, whereas chemical-related illness is mainly from long term exposures.	More emphasis is put on microbiological - very heavily weighted. For example 1 microbiological sample every month and 1 chemical sample every 5 years.
Microbial, seeing the level of treatment. Relatively fewer chemical concerns.	The emphasis depends on the source of the water.
Microbial, there is no comparison. I just prepared a paper and I was actually able to extract some numbers showing that more people are getting sick from enteric water-borne outbreaks in Canada than from	There is more emphasis on microbial parameters. However, people are more concerned about chemicals and carcinogens than microbial risks because they don't know as much about them.

Table E14. Summary of Responses for Question C3

Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion?	How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs*. chemical parameters?
chemicals. We can look at these numbers and we know that we get enteric diseases all the time from water borne outbreaks. Most chemical risks are associations only (dose response extrapolation), it is not actual response, it is reducing the risks to 1 in 1 million. If there are microbes in the water people will get sick and people will die from it. You can't compare microbial and chemical risks for that reason.	
Microbial, and I say that because we have no idea what chemical exposures we are getting through water. We don't sample for chemicals as often and we are unsure at which levels some chemicals cause illness. Can't attribute it back if we don't know what we are starting with.	There is greater emphasis on microbiological in the guidelines. In dealing with this and talking to experts, microbiology is number one. However, there should be more emphasis in the guidelines on microbiology and sampling protocol on the various microbes. It won't necessarily apply to every system but providing examples (*i.e.*, in a rural area this is what you should focus on), like a risk assessment tool. You shouldn't have to test everything from a to z. Need to have a system to prioritize what to sample for.
Microbial, there is no question. I base this on the number of outbreaks that have occurred. Certainly we don't hear of chemical outbreaks. Maybe we have heard of high arsenic levels but we don't have any health problems from chemicals - this doesn't mean it isn't happening.	Chemical parameters may only be sampled once every few years. Unlike microbiological quality which is evaluated on an on-going basis. Health Canada has a group dedicated to microbiology so this tells me it is important.
Microbiological-related illness is more common. I base this on the communicable disease report (*i.e.*, cases of giardia) and my experience. There is evidence on the microbiological side.	Highest priority is for microbiological parameters. The guidelines don't put more emphasis on microbiological parameters. Rationale is provided for all types of parameters. There should be more emphasis on them in the guidelines and additional risk assessment tools to determine what to focus on for sampling. Review of microbiological guidelines is on-going whereas chemicals we only review every 10 years or so. Resources are allocated appropriately.

Table E14. Summary of Responses for Question C3

Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion?	How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs.* chemical parameters?
Microbial-related illness, based on experience, I can't think of a chemical exposure scenario that has resulted in illness.	There is more emphasis on microbial parameters.
I think probably microbial. I guess I came to this conclusion based on experience and just as far as microbial effects are acute and chemical effects are more chronic.	Absolutely more emphasis on microbial parameters.
Microbial.	-
Based on experience, I would say microbial, we have done much more sampling and post-Walkerton there is much more attention given to bacteriological parameters that don't have chronic illness as a health outcome.	Not aware of any emphasis on bacteriological parameters, the chemicals section is much larger.
Personal experience would be microbial. But I will preface that with I have no idea if there has been that type of analytical work to determine how much of the Canadian population develops cancer by drinking water with an exceedance of BDCM. From my own experience it has been microbial – far and away.	Yes, my emphasis has always been on microbial. Again, I am a front line worker and that is the thing that tends to affect my population so that is where I tend to focus my efforts. I don't have much information on what, if any effects the population are experiencing. But when I am faced with *E. coli* or crypto contamination events, that is right now. Not a 1% increased risk to develop cancer over a lifetime. We tend to deal with immediate issues because that is what is on the public's mind. In the guidelines, I think there is much more emphasis on the chemical side. The microbial is pretty straight forward. The science is not that difficult to interpret. Whereas with chemical it is much harder to say if you ingest water this will happen *vs.* with microbial there is much more cause-effect correlation. The chemical side requires much more analysis and interpretation. I think there is much more emphasis on chemicals and again there are many more chemicals to be concerned with. There are only a few microbial parameters.
I would say that probably microbial. In	No question that there is greater

Table E14. Summary of Responses for Question C3

Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion?	How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs.* chemical parameters?
BC, 60% of the outbreaks in the last 30 years have been parasites and the other 40% have been bacteriological. I think it is tracked better – there is no question about that. In chemical exposures, the health implications of drinking water that has a high parameter in it are not going to be immediately evident – so that is one of the problems. Whereas if you have a microbiological outbreak, the effects are immediately evident and it is easy to know when you have a problem. Certainly, The Walkerton's of the world get the press. It is tougher to know – how do I know, suspect or even know to test for uranium in my water – the effects are going to be very slow at developing. It could be a very long ways down the road before the symptoms get sufficiently broad enough and at high enough levels that someone actually takes notice.	emphasis on the microbial parameters. Just in [our region] last year I think we analyzed 9,000 coliform samples on our water systems and that is just drinking water. I bet we did, we would be lucky if we [analyzed] 30-50 chemical samples.
Microbial, based on experience. I have been in public health for the last 30 years and I have seen very few cases of chemically induced illness from drinking water and lots of infection. I think the epidemiology is overwhelming with microbial infections being the main one.	I think there used to be a tendency to weight the chemical parameters more important than the microbiological but I believe that has changed recently. The guidelines do a good job of discussing them although, because of the number of parameters it seems to weighted towards the chemical and physical and parameters. Sometimes you have to dig into the background documentation. People will tend (the general public) with only limited experience, to focus more directly on the chemical parameters of concern.

Table E14. Summary of Responses for Question C3

Which would you believe to occur more often from drinking water in Canada, chemical-related illness or microbial related illness? How did you come to this conclusion? On what evidence do you base this conclusion?	How does this impact the relative application of drinking water quality guideline values for microbial parameters *vs.* chemical parameters?
Microbial, without a doubt. As part of our work, [we] have always played the lead role in drinking water quality and information. So we have always monitored bacteriological quality and with that we have looked at all communicable disease and enteric illness reports that are required to be reported throughout the province. That data clearly shows that we do have a fairly high level of people coming down with enteric illnesses in this province and some of those would obviously be related to drinking water. Based on microbiological standards for total coliforms or fecal coliforms we place numerous (I have probably placed thousands) notifications (*i.e.*, permanent boil water advisories) on public water supply systems. So I think we have an awful lot of associated information in regards to that.	I think there is definitely more emphasis on the bacteriological results, microbial guidelines and our efforts in working with water suppliers in this province. Yes, I definitely think the GCDWQ are presented in a way that reflects the relative importance of the microbial guidelines. I think there are references in the guidelines that really say that microbial risks are by far much higher then a lot of the chemical risks in drinking water. However, I think as we improve drinking water quality from the microbial risks, we start concentrating a lot more on the physical and chemical characteristics in the drinking water. I think [the public] would put a far higher emphasis on some of the chemical and physical characteristics than they do place on the microbiological ones that have a direct impact on their health.

Table E15. Summary of Responses for Question C4

Health Canada has developed numerical, health-based, drinking water quality guideline values for numerous (approximately 64) chemical parameters. Do you think that each of these chemical parameters all warrant the same level of attention? If yes, why? If no, what should the level of attention depend on?	Do you think that the *Guidelines for Canadian Drinking Water Quality* are presented in a way that adequately reflects the relative levels of attention that are warranted?
I guess not. No, I mean, which are the ones you're most likely to run into? Lead, arsenic, fluoride you know, like maybe there should be 10 priority ones that have to be revisited more often. You're in a tough spot because you've got other agencies like EPA where they're highly funded or that are doing a lot more reviews with a larger body of evidence and a larger number of chemicals. I think we should look at priority - what are we seeing most often as the problem? You know, I don't want to see them waste a lot of time on pharmaceuticals right now just because it's sexy.	I just don't see it in a hierarchy but I think you could pretty realistically look at what are the most common and which have the most dramatic health impacts.
No, they should not be treated equally. It should depend on the potential health effects, the type of exposure (whether it's acute, chronic or sub-chronic) the type of health effect (cancer or non-cancer) and the population that's most at risk (children versus adults or pregnant women). It may also depend on any history, if there's a contamination event, the concentration of a substance and how much it exceeds the guideline, and the actual circumstances.	If you read through the technical documents, somewhat sure. But that's no all that obvious if you are just looking at the summary table or if you are trying to recall the guideline for a particular chemical without that technical supporting information at hand or even if you are aware of it you know.
Yes.	-
No, I wouldn't say that. I think a lot of times what's bad about…the problem with science is we are too curious – we create more problems than we necessarily need to. I think it is better to focus on the ones that we do have good hard science about and stop speculating so much. The level of attention should depend on good science, coupled with things you can explain well. You have to have a mechanism there that you can either explain it well or there's already a level of understanding versus worrying about something that's more perceptive. Chemicals that have guideline values that have more science backing them warrant a higher level of attention in general.	No.
No, the level of attention should depend on risk	No, they are presented as being

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ranking.	all the same.
No, certain chemicals warrant more attention depending on the effect the chemical has on humans and the amount we know about the chemical.	No but this is not the role of the guidelines. It is up to the individual to decide how much attention is warranted.
No, it depends on the environment around the water supply. For example, there's a guideline for MTBE which is not used in [our province]. So why would we be worried about monitoring for that. Another one is TCE. And then we base our comments and position on advice from Environment in regards to what they're seeing through their monitoring of the ambient water quality. We don't see any protections from the province so why would we be focusing our time on those couple of guidelines?	Well I think there's probably room for improvement there. I think that for the individuals that are not actively involved in the application of guidelines, they would probably think that a water supply should be tested for all of the parameters. From time to time we have to explain why we're not testing for [certain things]. I guess it would help if there was some sort of, further explanation in the guidelines or in the document that details when these parameters should be tested for.
No, the level of attention should depend on the amount of certainty surrounding the MAC. If we are less certain we should only establish an IMAC. It is great to use the best available information but how useful and practical it is at the implementation level is another story.	I haven't looked too closely but I would have to say No.
I really don't know. I guess because we just don't deal with them that much. It is just a guideline anyway.	I would think [Health Canada] would have more concern for those they would consider carcinogenic but apart from that I really don't know.
No, it should depend on the degree of the health risk. For things like pH, calcium, and iron should not focus on these aesthetic objectives. Should concentrate more on parameters with potential health issues.	Yes, but the problem is the public does not understand AOs *vs*. MACs. I know it is difficult to write a technical document for the general public but it would be nice to have some sort of document for the public. I like the fact that they have two

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	distinct categories health-based and aesthetic.
Each one will have its relative health risk, not all of them are equal. The level of attention should depend on frequency of occurrence or level or severity of possible illness.	-
Not all chemical parameters warrant the same level of attention and this differs by water supply. Maybe some of the stuff around herbicides, for example does not apply to some systems.	-
No, the level of attention should depend on the characteristics of the water you are working with. A screening tool to help prioritize would be nice.	Could do better.
No, because all of them are different. Health effects are different, what they mean is different. For example lead is based on children, arsenic acceptable risk is 10-4. You have to understand each one of them to understand the risk and understand if those parameters may be in the water or not. Monitoring for all of them is pointless You should look for the most common chemicals that might be in the watershed and concentrate on those. There is no way everyone can sample for everything (well they can, some do).	No, they are not presented in a way that reflects the attention warranted because if you look at the website all the MACs are equal but we know that the risks are not. Some compounds we will never find and others are very common. It is not Health Canada's role to provide direction on what to sample - that falls under provincial jurisdiction.
Absolutely not. Chemicals are a derivative of something else. For examples, source water is huge, where are you getting your water from, the basin you're getting it from will determine a lot of the chemical characteriztis. For man-made chemicals, you need a point of introduction.	No but we are very close to sampling for all parameters with guideline values.
No, again for carcinogens it is the goal to have the lowest concentration so they would take priority. We want the lowest risk possible.	-
No, it should be based on health risk to the population.	Yes, by using health-based MACs and AOs, adequately reflects relative importance.
No they don't all warrant the same level of attention. This should depend on whether they pose a health risk - if they are health related they require more attention. Actual prioritization is site-specific. We	No they are presented equally.

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can't do everything, need to do a site assessment to decide what to sample.	
No. The ones with established MACs are most important, then IMACs and then AOs. Known carcinogens are more important than non-carcinogens (*i.e.*, arsenic is more important than THMs).	-
No, there are going to be some chemicals that you are more concerned with and you will pay closer attention to those (*i.e.*, what is in the area, *etc.*) it will depend on where the system is and what type of source water is used. There is no tool available to identify what parameters are more important, it is more common sense.	Probably not, they are all lumped together into a big long list of what the guidelines are. For many of the parameters, they wont be a concern at all.
No, should be based on level of evidence and health effect. Some, definitely, others, not necessarily (aesthetics, appearance, odor, *etc.*)	-
Yes, they all warrant the same level of attention.	Yes.
No, should focus on chemicals that do pose a health risk.	No, they are grouped together.
No. I know that some of them are aesthetic only so they don't require the same level of attention but what I have always maintained is that when people are dealing with foul tasting water, there is no immediate health risk, switching to bottled water could be a health risk. The aesthetic concerns will not cause as an immediate public health risk. Some of them are aesthetic parameters so they don't require the same attention. Some that cause more immediate health effects should be given more attention. For example, lead *vs.* elevated sodium.	I have never really reviewed the guidelines with that in mind. So I don't feel comfortable taking a position one way or another whether they are presented with that in mind.
-	-
No. The ones you will be dealing with on a more regular basis like arsenic, uranium, and lead – fairly common and higher profile. And the other ones, they are there if there is a suspect need to apply the. For example a contaminant from an industrial source, if we have got exposure that we know of, an old bulk plant or something, you look at the standards for things that are coming out of fuel. But how often are those things going to happen – they	I think the aesthetic objectives should be moved to a companion document so that all of the parameters that have a health related issue are in one document and all of the other ones based on aesthetic issues should be moved into a companion document so there

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Health Canada has developed numerical, health-based, drinking water quality guideline values for numerous (approximately 64) chemical parameters . Do you think that each of these chemical parameters all warrant the same level of attention? If yes, why? If no, what should the level of attention depend on?	Do you think that the *Guidelines for Canadian Drinking Water Quality* are presented in a way that adequately reflects the relative levels of attention that are warranted?
are very site specific.	is very clear separation between the two. Then you need to group ones that are more common than others.
No, it should depend on the actual health risk. It concerns me a little bit that we are focusing on the water quality numbers. The threshold for safe drinking water is quite different from the threshold for safe food or air quality. We have very tight control over what is considered acceptable exposure on the drinking water side but if you look at food we aren't as certain. Water is very tightly controlled and all of the other exposure sources are not. With arsenic the risk factor is quite high relative to other parameters. The ones we are primarily concerned with are arsenic, THMs, DBPs in general, turbidity and very few others really, nitrates as an indicator of nutrient contamination but there aren't a lot of other parameters that we have to really spend a lot of time on. It is my job to say okay, lets not focus on the pesticides or radionuclides, lets focus on the parameters of interest. We do some surveillance, especially of new water sources. I determine what to look for in collaboration with health inspectors, MHO, *etc*. and we sample the most significant features and use the guidelines as a guideline.	No. The attention being paid to chemical and physical parameters are of significance to other parts of the country. In other areas we do have issues with uranium in BC. There may be a great case for having all 64 parameters and they may all be important but you have to look at it at a local or regional level to determine which are important. My job is to take the information from the guidelines and apply it to real life situations.
No. I think there has to be a distinction made between those chemicals that cause a direct health impact and a health risk on an individual and those that are mainly aesthetic objectives that have physical characteristics that impact water quality but may not have a direct health impact.	No, I don't think they do. I think they are all just lumped in together and I don't think a lay person would look at them and think that there are various risks associated with them. The ones that the public are concerned with perhaps might be the pesticides and just think that those are the priority and not really look at the relationship and relative exposure they may have to something compared to some of the other characteristics. I think they

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	would put a far higher emphasis on some of the chemical and physical characteristics than they do place on the microbiological ones that have a direct impact on their health.

Table E16. Summary of Responses for Question C5

For how many of the parameters included in the *Guidelines for Canadian Drinking Water Quality*, do you think there is established evidence of causing human health impacts via drinking water exposure?
I have to assume all of them. I can't apply [the guidelines] if I don't make that assumption and I'm not allowed to ignore it because that's diligence. So a smart body of people will say there's a standard out there and they want to say it's a standard without any documented health risk. As an inspector I'm not going to argue. I'm not going to be allowed to argue. So that's the reality of when they create a guideline, if they're going to create a guideline, it's got to be applied or it's really kind of useless. So why should it be there if it doesn't have any possible health risks?
Probably 30 percent and that's just a guess - nitrates, lead, arsenic, fluoride, benzene.
I only work with select guidelines so I can't comment.
I always come back to the basics of the ones that are on a routine chemical water analysis. So you're looking at nitrates, sulphate, sodium…calcium, alkalinity, fluoride and chloride. So those are the ones that are predominant and not all of them have health effects associated with them. But I mean, they're the ones always of concern - fluoride, lead is not included it is in the metal analysis but fluoride, sulphates, particularly if you have someone who is already immuno-compromised. Those ones I think; they need to focus on more in terms of public health than getting into THMs, HAA and even the trace metals. Well some people will argue arsenic. Lead. There is not established evidence of causing human health impacts from drinking water exposure for all chemicals which have MACs established.
Not many, bacteriological for sure, maybe lead and fluoride.
A few, lead, arsenic, microbiological parameters.
Don't know - microbiological parameters, lead, no idea.
I don't know - lead, arsenic, *etc*. Some of them are aesthetic objectives as well. I would say roughly about half or three quarters of them.
No idea, I would hope most of them or all of them.
I think arsenic is the primary chemical one that we deal with that has a well established history of problems and I guess THMs would be the other. Lead, mercury - those would be the ones that come to mind. Fuel or diesel spills so benzene and BTEX. Although we don't deal with them, pesticides also and other more obscure things. THMs are mentioned almost every day. A handful.
No idea. I would have to guess. The reality is that I don't know.
I would hope that if there is a MAC or IMAC that they have established that. I would hope that there are not established guidelines for a parameter that we have not had a concern with.
If there is an established guideline value, I assume that there is established evidence.
Most of them would have established evidence but that would depend on what you mean by established evidence. You can argue forever whether there is evidence or not for some parameters (*i.e.*, DBPs). Chemicals would include lead, arsenic, fluoride, *etc*. but nobody can say that for any of those chemicals if you drink water that has concentrations above the MAC that you will experience the health impact.
Good question. I am not even going to guess. Basically we are looking at something that is under-researched and under understood. There is tremendous uncertainty. If you have to extrapolate health risks, you have to start with epidemiological studies and who knows what exposures people have in a lifetime, there is so much uncertainty.

Table E16. Summary of Responses for Question C5

For how many of the parameters included in the *Guidelines for Canadian Drinking Water Quality*, do you think there is established evidence of causing human health impacts via drinking water exposure?
Everything has proven health effects. If we see something in our drinking water we talk to Health Canada and they find out what the health effects are. If there is a health problem we have determine if it is from food or water and they will come up with a guideline. If there is no health effect, we won't have a guideline. So everything that is there has a health effect. If it is not a concern for drinking water, we will not have a guideline value.
I haven't got a clue. Not all of them, I don't think.
I don't know, I would have to look at the list - any of them that cause acute or chronic health effects. What about all the pesticides and herbicides that are not included.
I would assume all of them with established MACs.
Not all of them, definitely not. Probably a fairly low percentage, maybe half. They are just making an estimate of what you should be allowed to get from drinking water and there may not have ever been a case of ever having caused a disease. Established evidence for arsenic, lead, nitrate and maybe really high levels of copper.
I think for some of them, definitely. Some are based on aesthetics (*i.e.,* taste, appearance, odor). The level of evidence differs depending on the chemical.
I couldn't tell you. I would hope that suitable values have been determined but I am not sure if that is the case.
I am not sure, really not sure. I know that there is some but to quantify that, I do not have a broad enough knowledge of the guidelines. I would say it would probably be a portion because there are some where there is health impact but I would say maybe 60-70% might have quantifiable health impacts. Others may be more aesthetic or that type of thing. That is my best guess.
See that is the problem, I think it is only a portion. I think some of the guidelines are interpretive. They have done research, pure research, to demonstrate that there is some sort of relationship between exposure to a chemical and cancer in animals. And because of the type of things they see it means there may be a similar relationship in humans and therefore we need to apply a caution principle and be a little more cautious. For others we have direct evidence. I keep going back to lead but for lead we know that if you are exposed to it in drinking water at a certain level you will experience health effects. I would say that less than half of them have established evidence.
Only a few of them. The only case I saw involving chemicals was an arsenic case. Other than that I am not aware of any other case of people getting sick from chemical exposures via drinking water. Based on that, I would have to say that most of the numbers we are using are being developed on the precautionary principle and largely people's fears. You still have to adopt the precautionary principle and you have to have some starting point. But there is probably only evidence for a small number of them causing illness in drinking water. The guidelines are national so it may be quite different in Ontario with the lake system and industrial pollutants. Ontario *vs*. BC. If you are having a national GV it has to be broad enough to be relevant to all areas of the country.
Oh, I don't know, I would say a small portion of them perhaps. Not all of them that's for sure. Some that come to mind, I guess, lead.

Table E17. Summary of Responses for Question C6

When a water use advisory is issued as a result of a chemical in drinking water at concentrations exceeding the guideline value, secondary risks may be posed. Of the following secondary risks, which ones do you think have the potential to significantly impact public health? Rate the significance on a scale of 1-5 (1 = no significance to 5 = very significant). In your opinion, are there any other secondary risks to consider?		
Secondary Risk	Numerical Rankings of Significance	Comments
Inadequate Personal Hygiene	2; 5; 5; 5; 4; 4 to 5; 2; 4; 2; 4; 3 to 4; 2 to 3; 5	Communicate importance; depends on alternative sources being available; slight chance; very significant
Inability to Cook Nutritious Meals	2; 2; 1; 2; 2; 1; 2; 2; 3; 1; 1; 2	People are very resourceful; not a concern; it is less of an issue because we are looking at short term risks because the water advisory is short term; not major
Reduced Water Intake	1; 2; 3; 1; 2; 3; 3; 3; 2; 2; 2 to 4; 4; 3	The municipality would typically provide; that is a concern; depends on age
Stress/fear and decreased confidence in the water supply	3; 4; 3; 4; 3; 4; 2; 4; 3; 4; 4; 1 to 5	That is very important, I would put that at a 4. It is hard to quantify but the more situations we have with people being unsure, the more people we have turning to bottled water. And we have had many situations with microbial contamination in water coolers and bottled water is less regulated and presents more of a risk that treated municipal water; That's hard because it depends on how often you do it so if it's badly done and not well explained it could be 5. If it's good, it could be 1. There is a range; depends on length of time and effectiveness of risk communication
Re-allocation of limited personal economic resources to purchase alternative, more expensive sources of water	1; 4; 3; 3; 3; 3; 2; 2 to 3; 2	I would say that is about the middle; Something I don't often consider but a concern for sure; There are better places to spend that money. Paying $1.50 for a bottle of water when you are not spending it on nutritious food, that is an issue; water would be provided; I don't put it as high because predominantly there is an alternate source and the municipality will provide an alternate source. Now if you choose to buy from a store, that's your choice. But the basic necessity is provided by the municipality. - assuming alternative water source is made available

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Not washing produce prior to eating	2; 3; 1; 2; 3; 2; 3; 2 to 3; 2; 2; 5	Not concerned; You can wash all you want and you will not likely get it all off, if there is something there; yes, that is an issue, we have had a number of problems with contamination on the outside of the product; would wash with alternate water not a concern, could use bottled water.
Not cleaning home/office	1; 3; 1; 1; 1; 1; 2; 1; 2; 1; 1	Assuming short term only; not a concern at all.
Personal Injury	4; 3; 2; 3 to 4; 2; 3; 4; 3; 2; 2; 3; 1	No reports of scalding, lifting not a big factor - adds a bit of risk; big secondary risk; low risk with the provision that instruction is given on properly boiling water
Others/Comments	Another secondary risk is people going over to bottled water for the long term; Another secondary risk is obtaining water from a non-approved source (3); In current position do not apply the guidelines for this purpose; Political risks; Closure of schools, hardships for healthcare facilities (5); people continue to consume anyway (5); Finding an alternate, less safe source of water (2); Impact on health care facilities, schools and restaurants (4-5); The public could get water elsewhere; Impacts on health care facilities important but it depends on the duration; Tall secondary risks are relative to time. Other secondary risks include breaking from regular routine, stress on health care facilities, emergency response, other resources; alternative sources of water that are not safe, health care facilities, physical issues; Assume using bottled water, the length will impact the significance of the secondary risk so it is variable; It all depends on the actual risk - initial primary risk; False sense of security is public thinks boiling water will address chemical issue; health care industry 3 or 4; Getting water from a stream and driving further distances; Getting a treatment device and having a false sense of security, finding an unsafe alternate source of drinking water. Management of secondary risks needs to be included in the messaging; Impact on health care facilities - that is a major impact that does come in and requires us to bring in the bottled water for the short term.	

Table E18. Summary of Responses for Question C7

How do water advisories impact the public's confidence in the water supply? Is this relevant to protecting the health of the public?
Well, a water advisory will decrease the public's confidence in the water supply. It might increase the confidence of the public in the public health system or the environment department in that they're doing their job. But it will decrease their confidence in the water provider. Yes, it has to be relevant to public health in that there is a cost associated with advisories no doubt but theoretically, the department's issuing the advisories are balancing that cost with the cost of potentially clear health impacts. Difficult; more difficult on chemical than bacterial or microbiological.
People are going to start losing confidence and become complacent if it's repeating advisories or if it's long standing. Does that impact the public's health? Absolutely. You want to make the advisories as meaningful as they can be by assigning and preserving a certain level of importance. Also, the entire decision making process when it comes to issuing an advisory has to be meaningful and you have to be able to demonstrate to the public how meaningful. If it's not communicated effectively or if there's any kind of confusion over the advisory details, the public's confidence just goes right out the window. It's extremely important to do it right and to get buy-in of the other agencies to the importance of the advisory. Personally I think there should be some kind of regularly occurring follow up survey to the public or to people that were affected by an advisory to get some feedback about how effective it was. Because I really don't think we understand how effective these advisories are. They have very serious and significant lasting impacts on the public's confidence.
Big impact on the public's perception of the safety of the water. When there is an advisory they think something is wrong. Public is not really affected but they might start using bottled water and there is nothing saying the water quality is any better. They may panic and be scared. May be more risk from bottled water than tap water.
I think if they're used carefully and wisely, they can provide a good degree of confidence; not so much in the water supply but in terms of it being monitored appropriately. That they trust the agencies that look after their water. I think if they're used discreetly – now if that authority is always jumping to using them, then you're risking losing confidence and it brings in the question of, of what happened, why, why are we doing this? I think it really depends on how often you use it and how well you communicate it. It can go either way depending on how well it's handled. And this could pose a risk in that some people may choose an alternate (less safe) water source.
Obviously when you have to take any drinking water intervention it is going to have some impact on their level of confidence in terms of when you lift that advisory and whether or not you actually make it safe to drink again so a decreased level of confidence. But that would wane after a little while. This is it relevant to protecting the health of the public. I think you have to take it into consideration before you take any action; you want to make sure that the action that you're going to take is sensible. That you really have to do something there.
I think it dependent on a number of things. If there is a long standing advisory in effect. I think people tend to be, become complacent in terms of the actions that need to be taken when they're using that water.
Initially may have a negative impact on confidence but in my opinion it is also a positive because it also tells the public that someone is monitoring the water supply and as long as it looks and tastes good all is fine. People have a lot of faith in what comes

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out of their tap. The public shouldn't have blind faith anyway. Confidence is very relevant to protecting public health. Most people are fairly confident with the water. Less confidence means they ask more questions suppliers are challenged and held more accountable. The more knowledge the public has and the more interest they take in it the more careful we become.
If the advisory is based on a reported exceedance, the confidence remains high. If the advisory is the result of a known exceedance, it shakes peoples confidence. People generally take the safety of their water for granted and don't tend to think about it.
Absolutely relevant to public health. Firstly, it is important to communicate to customers receiving the water. They should be advised if there is a change in quality, although there is resistance in the municipal world. It is a political embarrassment if you are unable to achieve a level of service the people expect and there is unwritten pressure to bury the issue. Advisories are important.
Interesting question. A large number of people don't even know when an advisory is issued, so their confidence is no different and they continue to drink the water. Not clear if not getting message or if there is message fatigue. For some it has a huge impact on the public's decision making. It can have a negative impact and the result is no confidence in the water supply and people don't drink the water. Demand for bottled water increases.
Advisories are a positive thing. People have confidence and they should know that they can make a choice. Suppliers might disagree. It is relevant.
Increases confidence.
Negatively, certainly at the beginning. It is extremely relevant. We are consumers as well and we would not mislead the public we need to let consumers understand that. Public confidence is huge.
If used wisely, they can be very effective. If abused, there is apathy and the advisory is not taken seriously. Sometimes relevant, I think there is a lot of butt covering in the process. There is real *vs*. perceived risk and we pander to perceived risk and we tend to be motivated by politics.
They have a negative impact, especially depends on the way it is handled. When you issue an advisory, everyone is never 100% happy. It is relative in the fact that you want them to have confidence in the advisory. If they get an advisory too many times they get message fatigue and stop listening to the advisories all together.
People will think what they want. Confidence will be affected because people generally assume that the water is unsafe and will no longer consume. They will think that bottled water is safer. Water advisories in smaller communities, multiple boil water advisories. Public perception is important.
The more situations we have with people being unsure, the more people we have turning to bottled water.
When the public starts to loose confidence in their water supply for whatever reason, they make decisions on their own to go to bottled water or put their own treatment system in. I have seen a couple of cases where water advisories have damaged confidence.. I would suggest that is a fairly natural reaction.
In terms of the public, experience tells me that they like to hear from public health people when there is an issue. They like to have the information upfront and make their own health decisions. As a whole, it increases their confidence in public health

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and in us being a watchdog on their behalf. On the other side, industry would rather deal with their problems internally and not have the public so knowledgeable about what they are doing. Industry, in particular local and regional governments, tourism and hospitality industries, they are not real keen on that. It depends on who you talk to. No question that an advisory can have a negative impact on confidence if not handled properly and one of the big issues is message fatigue. When we are communicating this there is a fine line between communicating enough to impact the consciousness of the community as a whole *vs*. doing it not enough so the message doesn't take hold *vs*. doing it too much and everybody gets immune to it.
Interesting question because we are going through that whole thought process right now. In my area, and in the province in general we issue boil water advisories when we are not certain that the water is safe to drink from a microbiological perspective. We have a very low tolerance for that and we will issue a boil water advisory even if we don't have sufficient sampling data. So we are hoping that the public's confidence will be increased or the public will be heartened by the fact that we are on top of it. By issuing advisories when we are uncertain or know that the water quality is unacceptable that they will take some confidence that the water will be safe. We are hoping that the public's confidence will be improved by us being forthright and honest and calling it as we see it and making them see that we are not in the business of experiencing with their health. However, on the flip side they may look for alternative sources of water. We are trying to a get a grip on what the most appropriate risk communication messaging should be.
I do think that it increases the confidence in the water supply. I do think people want to know what is wrong with the water and what is the risk to them and what measures or actions they can take to protect themselves. They want to be able to make that decision. I think if there is going to be a decreased confidence in the water supply it is mainly because they are becoming increasingly aware of the poor status of their own infrastructure of their water supply system. But I think if everything is fine and they are aware that something has gone wrong with their water supply, I think that increases their confidence in the water supply in that at least they are being told the water is bad and the rest of the time they can quite safely assume that their water is safe.

Table E19. Summary of Responses for Question C8

Health Canada's mandate and expertise lies in protecting the health of all Canadians by developing the *Guidelines for Canadian Drinking Water Quality*. How effective are the current guidelines at protecting the health of Canadians within your jurisdiction? How, specifically do you know this?
It's tricky because some provinces adopt [the guidelines] into regulatory structures and some don't. Some provinces are using them to dictate how often people sample - but not to help with infrastructure upgrades and maintenance. From a client's monitoring point of view, they're successful in that we're not seeing a lot of illness relating to water supplies. I don't know if you can say that credit goes to the guidelines or does it go to the municipalities or the water providers or the drinking water regulators. Who accepts credit for that? So I'd say they're successful in being promulgated and adopted and used by health authorities and regulators. And we're not seeing a lot of incidence of disease. So that's a good thing. I think their mandate is a little broad. To say that their job is to protect the health of all Canadians by producing guidelines that aren't enforceable that are recommendations [is like] the federal government trying to bring a waiting times standard for all the provinces in health care delivery. You can publish a guideline all you want but whether someone uses it or chooses to use it or apply it is something else.
It depends on the substance. I would say they're very effective in protecting people at home against microbial hazards. They're effective at protecting consumers of additional exposure to microbial hazards but usually advisories are issued after the fact, after the exposure's happened. They're really only as effective as the people and the agencies applying them. To be effective, they have to really mean something and it goes back to established evidence of health impacts. Issuing advisories based on these guidelines and causing undue stress and anxiety among the public then, they're actually counter effective. Really hard question to answer. If water providers are meeting the guidelines, the assumption is that they're safe. So in that regard, they are somewhat effective in protecting the public. It's a hard, complicated question I can't answer. To tell someone who is pregnant that they might have been exposed to something that's been linked to miscarriage would probably cause more harm through the stress and anxiety than the actual exposure to the chemical. In some ways they are effective and in some ways they're actually causing harm. Yes and no.
We need guidelines. Without guidelines I would have to do my own research so I really need the guidelines for communication purposes. There is not a lot of evidence, it would be case to case. I think we could look at the population to decide. They help in the control of our drinking water quality.
Not very. The reason I say that is again it goes back to [the guidelines] being a good place to start if you are having an issue. Do they have significant resources? That's arguable. I want good science but the other part that I find from Health Canada is that it is not necessarily practical science. They provide you with the theory but they don't necessarily provide a method without major reconstruction of the entire system to deal with whatever the issue is. And the department will always look at the practicality of what it is going to cost. In particular, the public health inspector. How much more work with? That's where it comes from. So and they; the inspectors always want practical things. They don't want theory; they want to know what we can implement, what we can do without having to build a whole new water treatment plant and distribution line somewhere. I think that's where maybe Health Canada's shortcoming is – the practicality. But that being said, that's not necessarily a factor either because

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they're not supposed to be; they're not operational people. That's where Alberta Environment has engineers to compliment and interpret the guidelines. So I don't necessarily think that they overall, I mean their goal may be to protect the health of Canadians, but I think they need to bring down the science a bit so they can find new applications *vs*. Always being focused on the theory.
Well I guess to some degree they would be; they kind of make up the back bone of enforcement. So they provide the information or the guideline that tells them what they have to do to protect public health. There is no proof of health protection resulting from the guidelines, not that I'm aware of anyway. The general public doesn't even know the guidelines exist.
They are effective because they are applied but the guidelines only play a small part in protecting public health. I guess the method of determining their effectiveness is demonstrated by the fact that we don't have outbreaks occurring. But again, I think it goes without being said, the current guidelines are only one piece of the approach to dealing with water supplies.
I would say they are fairly good. Now what evidence do we have? I guess you have to look at the number of illnesses in the community, it is so hard to say because you can't put finger on it. We monitor for illness from pathogens and there is routine monitoring for microbiological standards. Through the infrastructure and testing and monitoring programs we have it is fairly good. But again, where we fall short is with respect to chemical parameters - don't know.
Very effective based on personal observation in that there are very few reports of occurrence of water-related illness. Absence of illness is good. Nothing in this health region for the last nine and a half years.
The guidelines don't protect anybody, it is our interpretation of the guidelines that protect people. So by using them as guidance, we get people to produce better water. What observations demonstrate this? This has been a peeve of mine for ages that there is very little research. For example our city has spent 70 million dollars to improve our treatment plant and distribution system and no one has evaluated the before and after effects. Vancouver is going through the same thing - spending 700 million dollars on filtration. We have no idea if there is a reduced prevalence of disease.
We don't have any information or evidence to show effectiveness so I can only assume it is working. Take them away and then maybe we can talk. Why chlorine? Take away and see.
In a lot of ways I believe they are effective. They provide a benchmark that water quality is set against and it provides a level of diligence with respect to sampling. That in itself builds protection because all positive results have to be reported to the health authority. The best observation of this is that the response times of health authorities after receiving positive results has decreased significantly and utilities have developed sampling programs and response plans. There are also some health-based indications where we have seen reductions in physicians billings. Another silent driver is liability insurance rates for utility operators - they know that in order to keep their rates low they have to do a number of things.
Quite effective. The guidelines set the framework. No evidence to demonstrate this but did not look broadly enough. Lack of ability to collect data.

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Not clear because the province can choose to adopt the guidelines or not and second, complying with the guidelines does not mean the water is safe. The health of the public is better protected than if we don't comply with them because most of the guideline values are chemical risk. Chemical risk is increasing risk and lower concentrations will decrease risk. There is no evidence available to demonstrate this (THMs is an example).
Evidence depends on a negative outcome. Have we had any major outbreaks? No. Do we have some small disease outbreaks? Yes. Are we quantifying all the outbreaks? Don't know. We have small amounts of disease. Do they work for us, you bet they do. It is an absence of disease taken as evidence. But is that the only thing you are looking for. The absence of disease generally it talks about the end of a long chain of relations. So how do you relate prevalence of disease back to water. Health Canada's mandate is to protect the health of all Canadians by creating a mandate. Their mandate is not to protect the health of Canadians by intervention. The provinces job is to protect the health of citizens.
We certainly need the guidelines but we don't know if it is the guidelines or something else protecting health. It is only a guideline.
They do an okay job by giving us a baseline to work with and there is scientific evidence as to why the numbers are created. Arsenic for example, lowering the guideline value is a good thing and it shows the people that we are progressing. Evidence in the absence of disease and water-borne illness, the fact that people are not getting sick from our water. It is tough to monitor health effects from chemicals and there is a huge safety factor and many other things in our environment that can cause cancer, for example.
As a tool, comparatively around the world, they are helping to protect public health. Can we do better? Sure. However, need to do additional risk assessment one systems to see if we can improve public health protection. We look at hospital data, medical visits, follow-up reports on communicable diseases and water-borne disease outbreaks. Numbers don't convince me that they are protective enough.
Yes, but to what degree I don't know. It is important that there is some number and for those that have been identified, they provide a guide to apply a standard to drinking water. It definitely assists and helps us as regulators and for those things that are known to cause illness it is important to have a number. Yes, from the sense that having no *E. coli* in your water protects health and there is an absence of disease.
Good information with respect to chemical guideline values for knowing what a safe level is. A good tool that we can point to for the public and utilities to have confidence in our decision. The guidelines are not the number one tool in protecting public health but it does contribute to health protection. There is no evidence to look at. From the chemical standpoint, there is no way to have evidence at our level. On the microbiological side, in a preventive health context it is hard to say for sure or get evidence.
That is a very difficult question to answer because we have our provincial standards that we follow. I think that the federal guidelines probably do, for sure have an impact on the safety of water. But f you ask me how much, I can't answer that.
Scientifically, I don't even know if we could answer that question. When it comes to

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microbiological parameters, and associated illnesses, the people on the ground would not necessarily tie that back to water. We don't have epi studies are limited by exposure assessment and specificity of the health effects. I think we take a lot on face value when it comes to predicting risks.
I am hoping they are effective, can only assume in good faith. If there is an exceedance it can be managed and remediated. Naturally high levels are identified.
I would say, not very in and of themselves. They are good guidelines but simply putting a guideline value out there does not protect public health. The application of a guideline is what protects the public. Health Canada is very good at developing very useful information for the field but they tend to forget that someone out there has to apply that. Just putting the guideline out there does nothing for public health if the local health inspectors or other authorities are not using these guidelines to ensure the water is safe.
That is a really tough one. The problem that we face in public health through all of our programs (water or food) is that we don't have good measuring sticks. It is very difficult for us to prove that we have an effect. Similarly, with the GCDWQ, how do you prove that their presence is having a positive effect on the population? You would probably have an easier time with the microbiological parameters. Specifically, because all of the chemical guidelines are based on lifetime consumption. So you get something like arsenic, unless you have been drinking water at or slightly above the GV, how do you prove that an illness is due to that or other factors or a combination. It is very difficult. You have to have a certain level of confidence in the people who are putting these guidelines together. I think they have an effect on public health by being there. Because although they are not enforceable, they are being used by various agencies and decisions are being made based on them. They may not be legally enforceable but they are certainly being acted upon to varying degrees.
They are certainly a very useful tool that we have used to good effect over the years to work through problems. Our 4-3-2-1-0 treatment objective is based directly on the guidelines and our turbidity program is based on the guidelines. However, the guideline should be re-vamped to provide better protection.
The guidelines are just guidelines but they don't actually do anything. It is how you implement them that protects public health. It is how you use that information that affects public health outcomes. HC can take the credit for developing the guideline – but they don't do it alone. HC plays a part but as do all of the guideline values. I don't think it is fair for HC to claim that they are doing it all on their own.
I think it is quite satisfactory. I think when I first started, it was quite typical for a lot of people would be coming down with outbreaks on giardia in communities and throughout health efforts I think we have heightened awareness on untreated systems that they should be boiling their drinking water and I think because of the heightened awareness and people using alternate water sources or boiling their drinking water, cases of giardia are probably showing some decline in this province.

Table E20. Summary of Responses for Question C9

So then would you say or do you think that monitoring to indicate that physical, chemical, microbial and radiological parameters are below the current guidelines, assures safe drinking water?
It raises flags. But it doesn't raise all the flags and it shouldn't be relied on by itself. It's just one part of a multiple barrier approach. You want more education. You want more infrastructure. You want trained operators to ultimately prevent this reliance on compliance monitoring. It doesn't matter whether you're doing infection control, water system's compliance monitoring is snapshots in time and it's not necessarily a predictor of health risk. It's more of a quality assurance program more than anything else. If you fail your compliance monitoring all the time, there's something else wrong. But it's not a guarantee.
A monitoring requirement is not risk assessment. There could be a health risk even though there's a compliance with the monitoring requirements. So in, in my opinion, it's not enough to say they're safe because they're sampling according to their approval or you know, whatever is required of them. It's not as simple as that, but it kind of lends itself to that type of simplicity if that is the way you're used to operating. it's a lot more involved really than just taking a guideline value and saying it's above the guideline so that means it's unsafe. Cause really that is really untrue. Before I was one of these kind of people that just took it for granted the guidelines were for people and that's what you based your decisions on. But since taking on the water position and specializing on that, they are great as a starting point and you know, for a lot, well, for many of the parameters that I've used in issuing the advisories or interpreting the results they're effective, right.
No, not really. The guideline is a guideline and it does not mean it is 100% safe. The guideline is needed but need to be reasonable because there are many areas for error.
No, only a snap-shot for a second. Monitoring really is just icing on the cake. It is your final physical proof in this case of no, I have no little bacteria in there that are harmful to us. And no, I have no amount of chemical that should be harmful to us over a short period of time or for longer periods of time depending on the chemicals. But it's not everything. It's much more important to be more focused on your raw water source. Much more important knowing you have a good operator in the plant and much more important that you don't have; you have a good water system and a good basic treatment system and filtration system as well good distribution lines. The problem is going back to the monitoring is the public wants to see the numbers at the end of the day and that's the only thing that they understand.
No, must be complimented with other programs.
No, there are other considerations like source water, limitations of sampling (only safe on given day samples collected), being aware of what is going on with the system.
No.
Yes, but nothing is 100% safe.
Yes.
No, there are other barriers you need to look at.
There is no assurance that the water is safe to drink but if the utility is delivering water that has met or exceeds the guidelines than yes, they are receiving safe drinking water.
Yes, if the water is sampled and meets the guidelines it should be safe but there are other considerations like real-time monitoring.
As part of a multi-barrier process, yes.

Table E20. Summary of Responses for Question C9

So then would you say or do you think that monitoring to indicate that physical, chemical, microbial and radiological parameters are below the current guidelines, assures safe drinking water?
No, compliance with the guidelines does not mean the water is safe.
Sometimes. You have done your test and it comes back negative, is that representative of all the microbes, no. Is it the best indicator? No, it is just a convenient parameter that was recognized as an indictor of human fecal pollution. It is safe based on the parameters we have chosen. Do we know them all? No. Do we know all the bacteria? No. Standards are meant for operations. The moment you meet your standard, you are done. When you are done your due diligence of testing, you are done, so your water can still cause a problem for some untested parameter but according to due diligence, you are done.
No. It is one of the main things but just because the guidelines are met, it doesn't mean the water is safe.
It goes a long way but it is not infallible.
That would be the first thing but also other things to consider. There are other triggers.
No, a multiple barrier approach is required, many components and sampling only represents a small a portion of the water.
No, it assists in but it does not assure safe drinking water.
No.
No, we are limited by current science and technology.
With the data you have at the time.
No. It is the same as any surface supply or subsurface supply.
No.
Absolutely - [helps to assure safe drinking water]. Part of it is the guideline itself. But it goes beyond that. If you just look at the microbiological standard and the recommended sampling frequencies, I have not been able to find any literature that supports the idea that those guidelines actually give us consistently valid data to assess water quality. Particularly when we go to the lower levels of sampling that are recommended. If you are taking 4 samples per month, the best you can say to the public about the water is that yes we sampled it. You can't really tell them, yes it is good or no it is not. So that is a problem. As for chemicals, again, one of the things that is not clear in the guidelines around chemical analysis is how to interpret what one sample tells us. It really gives us a snapshot during the time period when the sample was collected but does not tell us what is happening the minute before or after. The variability of how contamination is introduced and flows through the water column is significant.
No, it is only one component.
No, mainly because water quality changes very quickly and rapidly so to me just relying on monitoring is not the greatest. I think we are trying to rely a little bit more on process monitoring for the systems that do have treatment . However, that may not answer all things. Monitoring is absolutely essential. But if you are asking me if it guarantees that the water is going to be safe to drink all of the time – No.

Table E21. Summary of Responses for Question C10

Relative to other measures included in a multi-barrier approach to safe drinking water, how important are the specific guideline numbers (MACs) for ensuring safe drinking water?
They're a guideline and that's it. I wouldn't say they're the most important part at all. For some substances, it's open to interpretation and for other substances, it's certainly; they are important. Absolutely. For the microbial guidelines, I'd say they are very important. For chemical, they are important but as important as microbial.
Not the most important. As long as the treatment process is good, the guidelines may not be applied. Education is important.
They are a good tool to show the public that you're, you're doing it right. The public wants hard and fast. The regulators want hard and fast. Alberta Environment wants to know that you are not exceeding the chemical. Alberta Health, well not so much Alberta Health but the regional health authorities want to see you're not exceeding this chemical or you are not going over the limit.
Important for day to day monitoring but trained operators and plant maintenance are also very important. They are only a benchmark. An exceedance is not always a call to action and it is okay to have a mechanism in place to allow for slight exceedances that don't pose health risk.
There are many other considerations: source water protection, limitations of sampling. Need to be aware of what is going on with the whole system.
They are a small part within the multi-barrier approach. We could not function without them and they are important.
It is such a broad question. The guidelines are maybe 30% of the whole approach but certainly not the main thing. Need to look at source water protection, the process, qualifications of operators, sampling program. Need the guidelines and need to test the water as water can become contaminated. A part of the whole approach they are there for a reason and there is a purpose for them. For bacteria, those are most important and for others you try to do what you can.
Important to have the guidelines. They are fairly useful.
Everyone wants to know where the bar is set and it is difficult to set the bar at different levels for different people. So it is important to set a bar.
I think designers and operators need some criteria. The guidelines are just one of many items to consider. There are other things like trained and skilled operators - barriers are not just physical, they are also operational. It is important to have them.
There are other considerations.
They are part of the process.
The guidelines are nothing more than action and communication values. If you approach the MAC, you have an increase in risk. For me it is more of an action and communication value.
One component.
We need some numerical numbers. But the numbers are one of many things we should look at. We have to have a robust program from training, to how we design and build plants, how we operate plans. A number is only one of many things.
They provide the baseline. The multi-barrier approach is a result of the guidelines. We are trying to meet the guidelines values and depending on what the water situation is depends on what barriers we use.
I am not a big supporter of numerical guideline values. I feel more comfortable having

Table E21. Summary of Responses for Question C10

Relative to other measures included in a multi-barrier approach to safe drinking water, how important are the specific guideline numbers (MACs) for ensuring safe drinking water?
other barriers in pace because once you get results it is too late. Other things provide a better indication that the system is working. If the barriers are in place and verified than I know that for the most part we are okay. You need the lab reports to determine what barriers you need to have in place.
They contribute to the overall program. It would be specific. Certain ones play a very important role and others are not as critical.
The guideline values play a small part. They can help us identify hidden problems. There are lots of barriers: source water protection, maintenance, operator training, cross connection control.
The guidelines play a very significant role. It is nice to have a reference point to make determination on the level of risk. If there is nothing to compare water quality to, there is no way to do a risk analysis.
The numbers are important for a reference point. But I would contrast that with if you were to say that the MAC for antimony was X and y depending on this, this and this. How would we use that number? The health inspectors want a black and white number to compare it to so they can say yes or no. We are doing a lot of learning and coming to terms with how to make better decisions so we do need the numbers but we also need the understanding of what the numbers mean. So the numbers are needed but equally important is understanding what they mean. More and more [compliance monitoring] is being looked at as a secondary control check. We are relying more heavily on process monitoring and looking at what barriers they are actively putting place. Just looking at the bacterial monitoring as a confirmation step to ensure that the other barriers are working.
Well, there are two schools of thought. It depends if you are an engineer or an other. If you are an engineer, you like numbers because it tells you how to size filters and equipment in the treatment train – and certainly that is a valid approach and a historic approach. You take that approach *vs.* a process monitoring approach – so if we know that a certain type of filtration is going to reduce our turbidity this much when it is working well, do we need to test the turbidity or do we need to monitor the treatment process to ensure it is working at an optimal level. We need to do both. Given the cost of analysis on the polished water, I have a sense that it is cheaper to monitor the process. Again, it may be another step in the process to ensure good water is looking at process monitoring side by side with chemical, physical and biological monitoring. The question being if you have good process monitoring – do you need the other. You should have the confidence that your water is going to be good. There is always a place for auditing.
On a scale of 1- 5 around a 2. They are just one element of a process. Keeping in mind that we don't sample for everything all of the time. In terms of chemical or physical parameters we may have a small water system perform a general or physical nutrient scan every 2 or 3 years or less frequent. Bacteriological surveillance is much higher. We are looking for coliforms on a by-weekly basis. Don't necessarily adhere to minimum sampling requirements, in our health authority we will use a broad range of discretion in terms of other indicators of performance and historical indicators of performance and process monitoring. If good process monitoring and other elements in place, may not meet sampling frequency as outlined in the guidelines. Maybe 4 samples for month for microbiological sampling on a small system and

Table E21. Summary of Responses for Question C10

Relative to other measures included in a multi-barrier approach to safe drinking water, how important are the specific guideline numbers (MACs) for ensuring safe drinking water?
chemical/physical analysis would be done every 3 or 4 years.
Multi-barrier approach is absolutely critical to providing safe drinking water and some of the specific guideline numbers. It is difficult for me to answer that one. There needs to be some refinement and some better explanation of how they came up with these numbers which are part of the multi-barrier approach. So having specific guidelines or MACs for some of these things, I am not sure how viable or practical they are and how good they are in providing a reasonable approach. I think there needs to be some refinement around that. Without a doubt, I totally support the multi-barrier approach and we do need to look at a lot of things.

Table E22. Summary of Responses for Question C11

How much could chemical concentrations exceed a guideline before you would expect to see adverse health effects in the consuming population?
Exceeding guidelines in a regulatory structure, you're not supposed to do it. We may never see illness from exceedance of a guideline. So it's not how long after, it depends on what surveillance structure we want to put in place after a guideline exceedance. Do we have a skeletal fluorosis surveillance structure in place to look at exceedance of the fluoride guideline? Not really that I've ever heard. So you know, do we have a liver cancer surveillance program in place that's going to take place over the next four years to try and tie that back to a one time exceedance in some small town somewhere? It doesn't really exist as far as I know. We use the guidelines and apply precautionary approaches and say don't exceed these guidelines.
I really don't know. As a public health person it doesn't really matter when I would expect to see them. The idea is to protect the public. We just take the precautionary approach. It's not really important and it's not up to me to decide. We give the information to the public and then they can make an informed decision about what's important to them with respect to acceptable and unacceptable risks. So the priority for me is getting the information for water quality to the public along with the information on associated health impacts and how to protect themselves from those associations or links or established causes. The guideline's meant to be protective, just because it's above the guideline doesn't mean that you're going to see health effects. It's really challenging to try and understand what the significance is of the level that's exceeding the guideline level.
It is very hard to see health effects in a population, especially for chemicals. Microbial is different, you can tell if they are in drinking water, people are getting sick. Chemicals could be in air, *etc*.
I don't know. I can't answer that question. Everybody's different. On a community scale? If they were; if they were always at a 100? For example, and it suddenly jumps to 2. Maybe, maybe not. It depends. It really depends on which section of the public you're talking about. Sometimes sulphate numbers jump up really high for some reason. You know, will that result in an adverse health effects or that's just your body's natural response. Don't know.
Don't know, acute *vs*. long term.
Don't know, it depends on the chemical. I would hope that there's a fairly significant safety factor built into the chemical guidelines.
Don't know. That is for Health Canada to come up with - I don't want to go there.
No idea.
Don't know. It really depends on the chemical, what the exceedance is and the rate of consumption of the water.
No idea.
It depends on the chemical. Don't know.
Don't know. We are unsure at which levels some chemicals cause illness.
Compare to a speed limit. How much can you exceed before there is an accident, we just don't know.
No idea.
It is based on the uncertainty factor. Can we relax on some of the values for emergency purposes. For example, say we have a major disaster and we have no power to run treatment systems to their fullest extent, should we allow the public to

Table E22. Summary of Responses for Question C11

How much could chemical concentrations exceed a guideline before you would expect to see adverse health effects in the consuming population?
consume the water if the arsenic MAC is exceeded. What can you consume over a short term basis? First you want to remove microbes, boiling water, *etc*. But the other stuff, you can't remove everything by boiling the water.
I don't know.
It definitely depends on the parameter. For example, for carcinogens where we are looking at chronic effects, you could exceed quite a bit and you won't observe any acute effects. So I don't know.
Don't know, depends on the parameter.
No idea.
Acceptable exceedance if there is evidence to prove guideline values are not appropriate, need to bring the information forward.
No answer to that because there are so many and it is only one of the many programs we deal with and because we are a small health region (13 health inspectors including management) we get the information as soon as we get the results. For example, a bad arsenic result, we do our research, call on more experienced people in the larger centers (Capital or Calgary) and get their input and advice, what additional factors to look at before we make a decision. So as soon as we see an exceedance and we are not familiar with the parameter we start our research.
It goes back to the safety factor. For example, THMs (UF = 2100) *vs*. lead UF = (2), are we going to get particularly upset if we get one day of THMs that goes 10% over the standard *vs*. one day of lead that goes 10% over the standard – I don't think so. But you can't compare standards for different parameters – you have to be able to do a risk assessment based on a specific parameter and specific exposures and susceptibilities of the groups involved. If you are looking at it strictly from a health outcome point of view – a periodic minor exceedance is not going to be a problem but if you look at it from a liability mitigation point of view it is going to be a problem. Again it is balancing the need to protect and enhance the health outcomes *vs*. the practical needs of a community. If you can't get water you can't exist. If we do something that we know exceeds a standard, what does that do to our liability at the end of the day. For example, what is the difference between 1 *vs*. 1.1 part per million of fluoride? Well, it exceeds the standard but you won't see any mottling of teeth until at least 1.5 or 2. But again, there are some legal liability issues.
Don't know, different for specific parameters.

Table E23. Summary of Responses for Question C12

How do you believe the public expects you to implement drinking water guidelines?
I think the public wants education and knowledge. And if a government agency is going to tell them here's a guideline – try to stay under it for the best of your health or long term health or whatever, the public accepts that. But to implement a guideline, there's the whole resourcing. How do you achieve this guideline? How long do you have to achieve the guideline? Who's going to pay for you to achieve this guideline? There comes a point where the public just says that doesn't mean anything to me because I can't afford to fix it. You know, there comes a point where they're; they're looking at cost risk benefits and the same with municipalities really. Well, I think the public expects [illegible] health authority to take action when there's a guideline exceedance. And we've struggled with that because for the health authority to step in and order someone to do something like a municipality (one arm of the government to order another arm of the government to do something), it's a bit tricky.
Because they were given a guideline or they know they were given a guideline and that appreciation of it or that kind of an understanding of what a guideline is, the public's level of understanding, they would probably expect us to issue an advisory whenever a guideline is, is exceeded. Regardless of what it was. At least disclosure first and foremost. To let them know that they are exceeding the guidelines. Disclosure, issuing advisories when there's a concern. We've got some people that will be given a set of guidelines and then that's their Bible, right? And they'll just take it for granted that because it's a guideline, that's what they act on. But then when you actually look at the guideline and you take into consideration those uncertainty factors, like what is actually a risk to the public? It gets really kind of tricky.
For them it is very important. If levels are over the guideline they panic and they expect us to take action (fact sheet, *etc.* and spend money). No, the public does not understand the limitations.
However, try to explain UFs to the public and that's a different story. Cause we know the public steps on a number and if you're over that number, then it's not good news as far as they're concerned.
Monitor the water and compare against guidelines.
By the letter of the law. You are okay until you hit the number.
They expect guidelines to be standards/regulations. That's because people don't understand how the number's derived and what the, the MAC actually means. And that's always the challenge for people that have to try to explain the guidelines or exceedances of the guidelines.
To enforce them as hard and fast rules. This is what Health Canada has set out as the maximum acceptable concentration. That is how I would expect them to look at it.
Enforce the guidelines as standards at no cost to them.
It really depends on who you talk to. The general public is oblivious and has never heard of them. As a regulator we use them quite a bit as a guideline and they work adequately as a guideline. If they become a regulation, it takes away from all the other factors that need to be evaluated.
The public just takes it for granted that their water is safe, people don't reference the guidelines, it doesn't come up. Professionals don't even reference the guidelines by their name properly.
The may expect us to be sampling for all of the parameters - but the onus is on the utility operator to justify sampling program. The public has an underlying expectation

Table E23. Summary of Responses for Question C12

How do you believe the public expects you to implement drinking water guidelines?
that this is being done. But I don't believe the public really knows what that is. Never underestimate the ability of the public to learn. The public has the expectation that someone in government is looking out fro them but they don't know what specific actions are being taken.
Public takes it for granted that the water should meet the guidelines.
I tell them that I don't implement the guidelines, that is [Environment's] job. Mainly because my job is making sure the water is safe and that does not mean complying with the guidelines, we look at individual cases. Enforcing the number is Environment's job. Those who advocate safe drinking water guidelines do not understand what safe water means. Having numbers does not mean the water is safe or not. Someone still has to make a decision - the regulations can't tell you everything.
As law.
We rarely hear from the public regarding drinking water.
Consistently. I think we need to educate the public on the uncertainties.
The public looks at the numbers and it is either in compliance or not. They hold a lot of support for the numerical values.
They look at it as the standard, for those that are aware of them. They take it as matter of fact so if it says 10, that's what it should be.
As black and white. The public expects them to be implemented.
To ensure the guideline values are met.
The average person assumes the guideline values are being met. We also have the other extreme where people are very easily influenced by the media and trends. There is also a misconception that bottled water is better.
The public expects that water consumed is safe and that if parameters have guideline values established that the water is held to those.
Well, I believe that the public expects us to implement them to the letter of the law. Although it is not law, the public sees a guideline and they say that is where we should be at". It is always an explanation that the guidelines are only one part of out analysis of a situation. For example, if there was a water main break and adequate disinfection was done, but they took a sample before the disinfection we can be reasonably sure that the water is safe and will not institute a boil water advisory but the public would expect action – based on the exceedance not on all of the information.
I think the public, in a lot of cases, is not even aware of the guidelines from the perspective that they want safe drinking water and there are regulatory agencies in place who are responsible for that and they should do their job. [The public] doesn't want to hear about a risk assessment, they want to know can I drink the water or not. We are trying to start raising the issue because drinking water is usually not on people's minds unless there is a problem and is hard to convince the public if they are not getting sick personally that we need to [improve] treatment or source protection. Usually we are talking about spending a lot of money to get a rather modest increase in public health protection.
I would expect that the public expects an absolute application of the standard when it affects them personally. If it affects their personal health I would say they want absolute application of the standard.
The public expects that we are treating it like a regulation but we don't. The public does not understand how they are developed but if there is an exceedance or there is a problem they expect us to have a zero tolerance approach to exceedances.

Table E23. Summary of Responses for Question C12

How do you believe the public expects you to implement drinking water guidelines?
That is another difficult question. You are going to have those that have a very high level of knowledge and they are going to demand why this isn't this and why this isn't being applied and what are you going to do about it and there are others who have complete confidence that we have done a very good health risk assessment and as long as the water quality stays within certain parameters impacts to them are going to be quite low. Others are out there, especially if you are going to talk about the microbiological standards, they feel it is better for them to be exposed to the microbiological hazards than keeping them out of their water supply. So you run into the whole gamut of everything and you have to spend a little bit of time with the different fractions of the community so they have a good understanding of what the water quality is. However, from a health aspect most people expect the health authorities to look at these guidelines vary carefully and work towards compliance with all of them and assure them that the water quality is within those guidelines.

Table E24. Summary of Responses for Question C13

Do guideline values as currently presented to the public adequately portray the expected dose-response relationship and corresponding uncertainties?
No. I don't see them trying to portray anything to the public. They're producing documents that require high academic knowledge and background to interpret and the majority of the public that you deal with on a day to day basis, I don't see these Health Canada guidelines getting to them without filtering through other agencies like health or environment.
[Health Canada] makes a point of saying in the preamble or the introduction that the guidelines are set at levels well below what has been demonstrated to show or to cause health effects. But it's up to us to really deliver that message to the public. {A discussion of water safety] really almost always starts with a description of how the guidelines are derived and that alone is tricky. It's not helpful at all to have just one number where the impression the general public has is that if it exceeds that number, it's a health risk. If it's below that number, it's safe. If you really think about it, it's kind of dumb to present that to them that way. It can impact our service delivery and from there, the public's confidence in the regional health authority or even the federal guideline if they happen to have an opportunity to hear how they are derived and how they're presented. So I don't think it's helpful at all the way they're presented for the public's understanding. They may actually be harmful, you know, anxiety, stress.
I don't think exactly. It does not reflect the truth. Risk assessment never reflects truth it is just a tool for policy but there is not really a better way. A range would confuse.
No, I don't. There are so many uncertainties - just look at exposure assessment.
It isn't all bad. It is not easy to explain the dose-response relationship and we have to start somewhere and put something down.
No, but the general public does not understand.
Well to an educated individual, they do. And I think there could be improvements in regards to the way they are described - in a fashion that could be greater understood by the general population.
There are so many variables involved, is the problem with it. If someone detected benzene in their water, it would be very difficult to say yes it is there "but". How do you communicate the uncertainty? In my opinion, it is the wording. If Health Canada calls it a maximum acceptable concentration, it is hard to address the uncertainty when they are published as a MAC - they are set as hard and fast maximum levels.
No idea. The public does not know how to interpret the information. I barely understand it so the public can't understand. That is one of the problems with using a number, it is not exactly that cut and dry - I don't know if there is a better way - perhaps don't tell them.
The material has to be written in a simpler form. We deal with a lot of water purveyors and understanding the guidelines is beyond even individuals in the water business.
Health professionals promote the line in the sand because the public is not that knowledgeable about the values so less is better.
Does the public always want to know? I don't think so.
Is the term MAC misleading? Yes, because by definition it is an exposure. I am not worried about the public, I am worried about professionals understanding what MAC means. Health inspectors do not know enough about water.
No.

Table E24. Summary of Responses for Question C13

Do guideline values as currently presented to the public adequately portray the expected dose-response relationship and corresponding uncertainties?
People who understand the numerical values realize it is only one aspect. The public is not misled.
No. They don't show the factor of safety built in. It is comparable to best before dates. Just because there is a date on a jug of milk does not mean it is necessarily bad that day - may be sooner or may be later. A good analogy is that milk has an expiry date. If the date of expiry is the 3rd, it does not mean that on the 4th it is bad. We do have a percentage of people that take these numbers verbatim.
No, setting one number is misleading.
I guess if you know more about the background information and put that into perspective, yes. It misleads the public into thinking there is a line of safe and not safe. Arsenic for example should be ALARA but they want black and white, so 10 is safe. Public wants to know - is my water safe or not. I don't think there is anything Health Canada could do to change the "black and white" mentality.
Not really. It is going to vary for each parameter. We struggle with the black and white approach - we need to have a guideline but also need to adopt ALARA principle. In some ways when a government sets a standard it is easier for us to enforce it *vs*. a guideline. Just because you are at 9.9 for arsenic, it doesn't mean you are safe. We have to get the message out there that it is just a guideline.
This is a tricky one because the general public does not have an appreciation of what dose-response refers to. Peoples perceptions of risk color their understanding of what the guidelines mean.
No. Would love to hear ideas for a better system. Don't like ranges because they are tough to apply to the entire population.
You know, I don't feel qualified to answer that real well. Is there a better way? I wish there was but again dealing with health inspectors for 25 years, and water being only one of the many things we look at, they want a number and the health inspectors in the field don't care about the system just tell them what they have to work with so they can move forward with it. Is there a better way? Probably because we all know that 9.9 and 10.1 are in effect the same thing. But in the field people have to have something to work with and you do have to draw that line at some point. We also know that we error on the side of caution with the guidelines, which is very important – we have to do that. So we don't immediately panic when we see a minor exceedance.
No, I don't think so.
I think if you read the supporting documentation it does but the general public is blind to that or not willing to invest the time to investigate it further to understand. They, the public want to know is it safe or not and experience has shown that you need to be certain and not leave it up to them to decide.
I think that the supporting documentation is critical when using the numerical values in the guidelines and people have to be very aware that if there is a numerical guideline there they need to reference the technical documentation to get a good understanding of the health risk assessment that went into determining the numerical guidelines. I think that is absolutely critical if people are to use it in that aspect. I think where the question comes in is in the validity of some of the scientific information that went into it and then some of the compromise that went into setting the number. Realizing for a lot of these numbers, even after the best scientific information is out there will sometimes become a political compromise in setting that level.

Table E25. Summary of Responses for Question C14

If you observe an exceedance of a guideline value, what other types of evidence do you look at prior to taking action?
Depends on the community reaction. Communicate with other agencies involved. Collect additional data, consult with the community. Evaluate treatment.
I want to know the background on the plant. I will want to know what it did before. I want to know in terms of water quality. Let's say we're talking about water; what is their treatment levels? What will they add or change? I want to know what staff is there. New staff, old staff. Who took the water sample to begin with? Where's it analyzed? Can I see the results? And I want to see a retest.
I would look at past results, collect additional samples, would look at the enteric illness disease reporting system.
We're going to take into consideration the history of the water quality test information that we have from that water source, knowledge of the operator. The sampling procedures that was followed. The location we took the sample. The type of water supply it is and the condition of the, the distribution system. And you know, that, that'll cause us to think well maybe there's a good chance that this is a sampling error or a location where they took the sample and then we ask for a re-sampling of it.
For us, it depends on the chemical. Different information from other sources like the EPA, WHO, *etc*. and look at their parameters and what they are. We may even ask them to re-sample to ensure it is a representative sample.
Discuss with the MHO, contact local physicians for any effects in patients, check with public health nurses and look to see if there is a problem and based on the value, would make recommendations.
Primarily the population served, is it transient, high risk, a bunch of little kids? I guess the other thing is the political implications - but that is more for upper management. For example a ski hill exceeds the uranium guideline - why safe last year and not this year - a political issue. Not aware of any population health data that is available.
I use lots of information to help troubleshoot. Look for a change in the system, a change in the water source, a change in climate and any information operators can provide. Not likely that I would have any health-based evidence.
No, there is no population health-based evidence available.
Depends on what it is, look up EPA information, evaluate point of entry and use.
This would be the role of a compliance guy. That person would look at the operators, the type of system, the history of the plant, pat events. A variety of things.
If it is confirmed *E. coli*, I don't look at anything else, action is taken by issuing boil water advisory. With other situations ask questions, any plumbing activities in the house, any construction in the area, check chlorine residual and the treatment system, take another sample to confirm.
Be very thorough and look at all evidence like: history, any changes to the treatment system, past results, is there a chlorine residual, has there been a water line break, any history of false positives? In the absence of good information, need to look further and do a thorough inventory, any complaints? If suspect, take action. We have to be smarter with the evidence in front of us. In the absence of information we have to take more prudent measures.
Need to look at the source, would do repeat sampling to confirm first sample results, evaluate historical data if it is available but in most cases there won't be much chemical

Table E25. Summary of Responses for Question C14

If you observe an exceedance of a guideline value, what other types of evidence do you look at prior to taking action?
data, evaluate what is found and determine the source (naturally occurring *vs*. man made).
You look at the use of the water. How often is it used, how much is consumed, what is the source of the water? Will the concentration (*i.e.*, nitrates) increase?
Determine if there is a logical explanation of the exceedance, do on-Site investigation, is there evidence to support results of analysis?
Any antidotal information from the client, line breaks, construction, any water shed issues. It is hard to nail down exactly what we ask because every situation is different and there are a lot of questions that can be asked. We don't have any population health data available, the short answer is that we don't have that type of information available to apply to drinking water. I guess all of the water systems deal with relatively small groups so I don't know how valid the population data would be. Much of the data goes back to population data per 100,000 and our entire region maybe has 1.5x that so any water system could not give us enough of a population-based, meaningful data. The data is not available at this point anyway.
Obtain medical opinions as required (MHO, other experts).

Table E26. Summary of Responses for Question C15

With the development of more guideline values and/or the lowering of current guideline values, what type of responses would you expect to see within the population?
Lowering guidelines is a process that's difficult because sometimes you lower a guideline and wait. Give people five years to comply with a lower guideline or local agencies like environment might say you have five years to upgrade your plant. I think the general public is receptive to what they perceive to be an improvement in their water quality. So if lowering a guideline achieves an improvement, they would like that. If every time you lowered a guideline, you increased taxes by a hundred dollars a year. I think you would see some resistance for the better. I think that's a realistic perception that when it comes to protecting the public, lower is always better. If you're talking about health risk, I think on some chemicals lowering concentrations when the science improves such we can detect lower concentrations goes in the vein of precaution and let's get these chemicals as low as we possibly can because we're not sure necessarily what the impact is. I would generally see the lowering of things as better.
If you tell one person one year that this level of BDCM in their water is safe, and then the next year, all of a sudden it's not safe…it just confuses the public. And as a result of that we lose face and, and we lose their confidence. Because they're not looking at people that come out with the guidelines. They're not looking at Health Canada. They're looking face to face with us. We're the ones that are presenting these guidelines. We're the ones that are trying to protect their health by applying them, you know. I'm sure people have walked away from town hall meetings thinking the whole system's a joke, especially with respect to changing guidelines. Would I see anything to indicate improved health because of the lowered guidelines? Uh lead; yeah, you might see, depends on the substance. I know with lead, my feeling is that the guideline should be a lot lower than it is and you might actually see reduced exposure to lead as a result of plumbing. More attention on that. And then of course, you'd have a reduced exposure because of that and maybe less health impacts. I don't know.
Would not expect to see any improved health effects.
I don't think we would see any effects. I think you'd have to do; you'd have to do a double blind cohort study. This group gets this water, and this group get this water and look at it after forty years. Right? Cause that's assuming you could match every person in the data set to really see if there is an impact
The public wouldn't notice any changes in their water quality. As for health effects, not necessarily. How could we ever measure it? We treat to a high enough standard, any additional treatment only offers a false sense of security and would be very costly.
None with respect to health status of the population.
Won't see any changes in the short term. I think application of the number or the, the methodology of the number can just be as effective for say heavy use in some situations. I think that improvement of the understanding of what it means and uh…improved monitoring of certain guidelines is maybe uh…is more effective than trying to develop other guidelines in another area.
I would expect to see push back from the public on increased costs. Don't know if you would see health-related responses - maybe but I really don't know. I don't think there have been studies. We are doing a fairly good job as it is. Regardless, we can lower the MAC but people travel. May see a reduction in chronic illnesses but you would not see a big impact on the health care system.

Table E26. Summary of Responses for Question C15

With the development of more guideline values and/or the lowering of current guideline values, what type of responses would you expect to see within the population?
None, I don't think you would see any response. Unless it happened to be with something like arsenic, and the general public seems to know about.
The public will probably be happy until they realize the impact on the water purveyor and the infrastructure that they will have to pay for. Don't expect to see any improvements to health of the population.
What is the particular contaminant we are changing and what is the particular chemical and the outcome, how long would it take to observe the health effect? It would have to be done on a case-by-case basis.
Could not measure any improvements in public health if there were any. People would drink more bottled water and confidence would be affected.
None because most of the guideline values are based on predictions/associations only. You can never pinpoint anything to a chemical exposure and they are based on lifetime intake so you can't relate improved health back to drinking water quality.
There would not be and health improvement observed. Unless you can point to something that actually creates a risk, how do you know which one you have addressed. The worst thing to do is to waste resources on an unproven health risk and find out in the future that it means nothing. You don't gain any credibility by imposing regulatory stance without having a firm expectation of a change in the future.
Certainly from a public point of view, they want to see a quantifiable result. The numerical values help us.
In theory our health should be better but that would only work if we all stayed here but the fact that we all travel changes everything. In all essence, the water should be safer and less intrusive on a person's body but we all travel.
It comes down to money and cost. They will raise issues and concern and it will cost a lot of money. It would be difficult to measure any improvements to public health - cumulative exposures (via air, food, environment, *etc.*) make it difficult. It can go the other way too - why can't values go up when they were initially too conservative. Numbers usually go down.
It will raise more concern. Whether the concern is legitimate, that is another thing. The only ones that will tend to question it is the suppliers. With respect to actual health outcomes would not expect to see any improvement in the short term, definitely. Over the longer term it is doubtful. Given other routes of exposure, it is difficult. For ones with acute effects, you may see something.
There will be more challenges with lower guideline values and increased costs for treatment. It is impossible to measure any health improvements. The public asks questions when guidelines are lowered.
It is like the "swiss cheese" approach. We want to eliminate the risk so we implement a number of controls to close the gaps.
It depends on which parameter you are talking about. For instance, if conditions or science changes, *etc*. We have just asked for the tritium guideline to be lowered.
Even if there would be improved public health, we would not be able to measure it.
I don't know and in all my years in public health and I have not got a great background in population health statistics, by any means. I am where the rubber meets the road, front line field person. So I would hope that we would see some broad population improvements but I temper that by saying that the risk seems to be so low in many of

Table E26. Summary of Responses for Question C15

With the development of more guideline values and/or the lowering of current guideline values, what type of responses would you expect to see within the population?
these that I don't know if it would be measurable and I don't know how to separate out the risks from THMs for example and all of the other risks that cause these specific cancers and so on. So I don't know how that would be measured effectively. Anecdotally, I believe that yes, it would make a difference but whether we can measure it is another thing. If we reduce chemical contaminants in drinking water then we would assume that we would see less cancers and fewer adverse health impacts but how do you quantify that because I don't think we are seeing hundreds of thousands of cancers as a result of drinking water. It is going to be very hard to draw that link. Although, theoretically, it has got to be there.
That is a good question. I can't think of a chemical exposure where we actually have documented negative health outcomes. What are we going to see if we lower lead in drinking water in schools. I don't know if we see anything at current levels – hypothetical risk. But what does that tell us – we aren't looking or there is no effect?
No change. I would expect more resources to be spent on analyses. What I would worry about id diverting the public's attention away from the real health issues. As an example, we had an issue come up with CCA in playgrounds and what children were being exposed to and we were pushed into doing soil analyses and swabbing of equipment but our MHO argued that childhood obesity is the biggest issue we have – let them play and put a hat and sunscreen on your child to mitigate risk of cancer.
I would expect that adverse health outcomes on the drinking water users would be lessened. Take uranium and arsenic for examples, now just because the levels have gone down does that mean there has been a decrease in adverse health outcomes? I don't know. I don't think that we've got the scientific research. I am not sure the scientific research could ever be done. Now the flip side is that well, there are a lot of new chemicals out there for which I don't think there have been adequate guidelines developed for yet. I am thinking about the endocrine disrupters, the personal and pharmaceutical care products, things like that. Guidelines for those, I am not sure have been set and I am not sure at what levels and how they would be set and if you decrease those is there going to be an associated improvement in lessening the adverse health outcomes to individual users or not? I don't know. A lot of that research still needs to be done and guidelines and standards need to be set around them. So I would expect it to help and I would expect there to be lessened adverse health outcomes but that needs to found yet.

Table E27. Summary of Responses for Questions D1

In addition to what is already being done, do you have any other expectations of Health Canada when it comes to establishing and implementing the GCDWQ?
They could work on their communication structure and how they interact with the people, the public and the local agencies. They might want to look at some of their committee structures and decide are they a health agency or are they an environment agency? Because there are different mandates. I don't know how they come to some of their decisions and what things they've taken into consideration. It would be great if Health Canada wanted to take a leadership role in bringing health agencies and environment agencies together and looking at standards and guidelines. Or if they wanted to participate and ask us how useful we thought their guidelines were, you know, where are strengths, where are weaknesses. Have you tried to navigate the Health Canada website? It's not user friendly. The federal group can sit back and say our job is to only look at the guidelines by themselves and not look at how you achieve them. But when they do lower a guideline, that certainly puts the local agencies in a challenging position. I don't see much money coming our way to help us get out educational messages or deal with the public or deal with agencies to see people as they try to achieve these guidelines.
Just to revisit the guidelines regularly and make sure that they're based on the most current, available information. Also to improve the messaging around on how the guidelines are meant to be used and implemented. They have a few statements in the guidelines, but it's still left up to us to decide what we want to do with it.
We require a clear standard for what kind of evidence to use when making decisions because right now there appears to be an inconsistent use of evidence. Require a sampling strategy. Require implementation or action plan for guideline values that includes what action to take if value is exceeded.
They don't do a good enough job of including small water treatment plant operators. Their documents are much too technical for most operators anyway. Yes, there's regional representation on all these different working groups. But it's not necessarily at a level of practicality or application. I mean, cost is one factor, I am not disagreeing with that. But I still sometimes don't think there's a big reality check there for Health Canada.
A how-to guide for some things would be useful. More communication down to us. Additional responsibilities of provincial representatives to ensure regional needs are being considered.
No.
Pushing for small systems.
Yes, I expect them to develop guidelines based on scientific facts and the best available knowledge. Health Canada has people dedicated to this and I expect them to give us the best version of this that we can take to the public and apply to public water systems.
Yes, implement agreements between Health Canada and the provinces that guidelines are accepted and expected to be enforced. Currently just a guideline - no weight behind it.
More public relations to the general public about what the guidelines mean and Health Canada's role in developing the guidelines. I don't think that it is widely known that there are guidelines in Canada at all outside of the professional health, regulatory, research community. Sort of a mass marketing media-type thing that these guidelines are around and you should try to pay attention to them.

Table E27. Summary of Responses for Questions D1

In addition to what is already being done, do you have any other expectations of Health Canada when it comes to establishing and implementing the GCDWQ?
Yes, educate and promote. An education campaign to educate the public, operators, customers of the product, suppliers, designers, health professionals, *etc*.
1. Communication with respect to what is the expected use of the guideline; 2. Explanation of how the numbers are set. How do inspectors sell it?; 3. How does Health Canada fit in?; 4. Expectations of Health Canada for the provinces to implement.
Presentation - risk assessment tool related to guidleines; it would be useful to look at how the guidelines fit into the multi-barrier process.
Health Canada is doing a good job and they have improved over the last five years. The problems we face are with the people who use the guidelines. Some issues with development like lifetime exposure and single exceedance for BDCM. Would not advocate national standards - regulations don't tell you if the water is safe and lower guideline values do not mean safer.
I don't have any expectations of Health Canada at all and there is no mechanism to get involved. This is a matter of health and health is a provincial responsibility not a Health Canada responsibility. As such, everytime Health Canada involves themselves they have questionable authority to require a national scope of anything in health. If drinking water is a health concern than they have to go for said disagreements with every province. If it is an environmental concern than their scope is broadened which is why alot of this stuff that has health undertones, is funneled through environmental applications. Public Health in the provinces is not a derivation of Health Canada.
Health Canada has no jurisdiction, except for on federal land. We have a robust program and we don't need Health Canada to get involved. Not much we can do to make it better.
Honestly, no. The only one would be that they continue to keep up. Continue to keep up with technology and ensure that the people in the department doing the water analysis have the best equipment and knowledge.
I would like to see a range of values. Setting one value is misleading. It would be nice to have more of a risk assessment tool. This GCDWQ is the only guidance we have at the national level. We need a mechanism to offer input and give information back to Health Canada to say "can you consider this in your review next time".
For my purposes the GCDWQ are adequate and they are laid out quite well.
I expect them to provide the health information and science so we can look at it, understand it, be comfortable with it so when we go to the public we can show them the science and the rationale behind the decision why the guideline was set. Currently they set a value and you really have to read into it - it would be useful to have a better way to articulate information to the public. I don't know how you would do that.
A lot of faith is put into the guidelines, in our area we go above and beyond what is required in the guidelines. For example, although it is not required we routinely test for mercury. It is important to establish historical water quality so when something does happen or there is an elevated concentration you have additional information to support decision making.
Cost of sampling for all parameters is a huge limitation. We need to find ways to trim down the testing regimen and streamline sampling program in an effort to cut costs. Would like to see more leadership at the federal level. Need to do more research. Post guideline changes. Health Canada could be more proactive in identifying potential

Table E27. Summary of Responses for Questions D1

In addition to what is already being done, do you have any other expectations of Health Canada when it comes to establishing and implementing the GCDWQ?
issues and assisting the provinces with technical guidance. It varies within Health Canada how proactive or consultative they are.
One thing that would be nice, not necessarily from Health Canada - smaller health regions could use more education and support
I think right now we have in our drinking water advisory committee, we do have Health Canada representation from first nations. Which is great because we don't have any input on water quality on reserves. I would think that some representation from the federal government on the guideline development side would be helpful to make sure that we are getting the message across in our field manual to provide to our health inspectors. We can access a lot of information over the internet. I would like to see more effort by Health Canada put into educating the people who are using the guidelines on the application of them and what they mean and how to best interpret them.
I would ask that there be a stronger push on all of the microbial treatment requirements. There should be a national standard for surface water or groundwater under the influence and at the same time there needs to be funding. It will most likely never happen.
The guidelines need to be re-vamped: 1. Health related parameters should be presented first and prioritized, 2. Should be able to receive a digital download (automated) with updates; and 3. A section that articulates treatment standards in the context of a multi-barrier approach. Should be all tied together to give a comprehensive picture of water - not just focus on guideline values. As for chemicals, again, one of the things that is not clear in the guidelines around chemical analysis and how to interpret what one sample tells us.
Health Canada needs to show leadership. Provide direction on what the risks and the drivers are and how to balance the risks. The problem is not in the development of the guideline values but with how they are implemented.
Not really. But one thing that would be nice is if HC would put on a seminar or road show or training session every year for once a year for each of the provinces to discuss what is happening. Maybe you get a bit of notification for which document is out for consultation and which one is out for comment and the dates and things like that but an actual training session for those that are actually applying these guidelines and using these guidelines presented by HC would probably be of benefit. Right now just posting it on the web page and expecting everyone to find them and figure out how to use them probably creates an awful lot of uncertainty and lack of consistency in approach. Whereas if they actually presented some guidelines on how to use them, what they meant what they did to them and provided that kind of an educational format/structure, that would be of benefit.

Table E28. Summary of Responses for Questions D2

Are there any changes you would suggest regarding how to apply chemical guideline values to ensure that water quality guideline values provide the most benefit for all and achieve their intended aim?
How to apply a MAC is not laid out so provinces need to prepare chemical exceedance guidelines. Health Canada could do this. I don't like guidelines. They're a minimum and just because we're setting a guideline doesn't mean you shouldn't try and make it zero. I think that's the proper or appropriate approach to take. As far as application, it is difficult to deal with real world scenarios without real world numbers and to try and choose a course of action that's consistent and reasonable. There's a lot of variability on that course of action that you choose and what you do. There's not many real world examples that the Canadian guidelines give you to say you know, given this type of situation, you might want to consider applying the standard this way. You've got a farmer who's got his hand up the butt of a cow every day and you're telling him you've got 10 total chloroforms in your wellwater, you know, where's the real risk? How do you communicate that risk? They're not always made relevant fully to the people who are at risk, the farmers, the rural people, the small municipalities, small co-ops. Like if you ask the health departments who are they dealing with on a daily basis, it's the small systems, the small operators. There's definitely been work done recently across Canada saying really, where should we be putting our resources, our money and it is the people who are at higher risk because they're not a municipality with loads of funding and trained operators. It's the small systems. I've seen wells in the middle of chicken coops, in the middle of corrals, feeding lots, downstream of sewage outfalls. Those have a much higher risk. But it seems like the Canadian guidelines have spent a lot of time dealing with a lot of chemical risks that I'd like to see them revisiting the bacterial stuff more often and more frequently
They could maybe include a sub-committee or something like that of people that are actually applying the guidelines to think of ways to provide examples of some kind of model for decision making when it comes to chemical substances. Like practical application, right? Maybe that's giving them several examples. A decision tree or flow chart or something. It would be probably just more than guidelines then. But it would be a much more wholesome resource.
Require more guidance on how to communicate with the public and how to manage risks based on exceedance.
Health Canada has to work at improving accessibility in terms of their whole commenting process for when these guidelines are developed or when guidelines are under review. I guess they could encourage the provinces to…not all provinces have accepted the guidelines - some have, some haven't. Perhaps parts of the guidelines should become national regulations.
It would be useful if the guideline documents could better explain relative risk in terms of different scenarios. For example 18 ppm for two days *vs.* 18 ppm for 2 years, *etc.*
We're looking forward to additional documents that are better being prepared or being planned for small water systems. It's a, for a large part, these guidelines are written in the context of a municipal water supply. Although there are some snippets here and there about semi-public water systems. But you know, in regards to sampling requirements, in terms of operation and in terms of distribution concerns or distribution treatment concerns, in regards to distribution systems and so on. So we're looking forward to that and if they haven't been doing that, so that's what I would be pushing

Table E28. Summary of Responses for Questions D2

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for right now.
No, I don't have a lot of information on how they develop the guidelines. Communication is important and they provide us with information on treatment and health risks. A lot of what they give us is scientific jargon which may not be as easily interpreted at a level that is applicable to the public.
If a particular parameter is a real health concern, maybe it should just be in a regulation.
Not really, the guidelines are around.
May be some merit in applying a water quality index to the quality of water - similar to what we do for air. It may be a good option.
The guidelines do not provide any guidance on which parameters you should sample for.
Provide a hierarchy of parameters - what are the big problems (As, THM, uranium, nitrates) and a hierarchy of barriers. Provide some additional step-wise guidance. Struggled with the turbidity guideline.
There needs to be more training and understanding for regulators regarding operational *vs.* health impacts.
No, because according to the constitution, health is not a Federal affair.
Guideline values are only one aspect of ensuring safe drinking water. Need to support the guideline values but have a program in place first. Need to evaluate the entire drinking water program.
Require common sense so "grey" wins over "black and white"
Should be a mechanism in place in order to prioritize what to sample for. We need a standardized risk assessment tool and triggers for sampling. There needs to be more guidance on guideline value application because the numbers are relied upon too heavily.
Federally they need to provide some guidance on what we should be sampling for and how frequently. We could use a better pool of resources - that is one area that needs further investigation. It would be useful to incorporate things like "you should sample for this when..."
Need to include consideration for emergency situations (*i.e.*, spills).
The federal government is lacking in leadership.
We can learn from other countries. Health Canada has to be more proactive in identifying potential impacts on water safety (*i.e.*, environmental changes, global warming, climate, *etc*.).
Would love to hear suggestions for a better system for situations where you are close to the guideline value; more standardization would be nice, consistency across regions and if we are dealing with similar situations should have the same overall approach to deal with it
Stuff has to be deliverable to the public and sometimes the approach is too academic. They need to recognize that most issues are with smaller systems and work to make improvements.
From a regulatory point of view, part of me wishes that there was a solid number and that everyone had to meet it. Particularly with filtration and turbidity. It would make life a lot easier if there was a national standard that said all surface water sources must

Table E28. Summary of Responses for Questions D2

Are there any changes you would suggest regarding how to apply chemical guideline values to ensure that water quality guideline values provide the most benefit for all and achieve their intended aim?
undergo filtration. The other part of that is that you have to back it up with proper funding and support. What we currently have now is – "well here is the recommended practice" and you should do it. We are not ordering you because it is not a regulatory standard, it is just a guideline. If we are not ordered we don't comply unless they have money or an order. Having guideline values that aren't enforceable can create problems in that they are not good for effecting change.
Ensure a higher level of accountability for critical issues. I would like to see them revamped and focused in very specific areas. One is to prioritize chemical parameters and have a top down listing. So it makes it a little bit more readable for the public and more useful for local and regional government planning and our internal staff. They should be, rather than being out in booklet format and only on the website, you should be able to get a digital download that has an automatic update to it so it is constantly current. It would be very good to again, have a section in there that articulates treatment standards not just in terms of what you should be doing but how do you interpret that against raw water quality and in the context of a multi-barrier approach. The multi-barrier approach stuff is also on health Canada's website but it is in a different location. It should be melded into one comprehensive document to provide a comprehensive picture of water quality and how to achieve it.
I have mixed feelings. In some sense I would rather they stay out of it. Some of the things they do are quite disappointing. I don't have a high degree of confidence in health Canada, so I would prefer they stay out of it. I would rather see some solid public health evidence for bringing in new numbers or lowering guideline values, knowing that people overreact to chemicals and the intended risks from them. I would really encourage Health Canada to not follow along with the public but rather show some leadership instead of steering to peoples fears.
I think that in the supporting documentation it would be helpful to use much easier, simpler language in discussing the uncertainty factors and discussing the rationalization of how they actually came up with the number. I think that would help with a lot of the discussion that happens in trying to implement and use the guidelines. Obviously they go through an awful lot of discussion in setting a number, like 5 NTU for not more than 2 days a year – where did that come from?

Table E29. Summary of Responses for Questions D3

Do you feel you have received adequate Guidance on the application of water quality guideline values? Who has/should provide this guidance? In What form should this guidance be provided?
We don't get much guidance from anybody on the application of the guideline values. The regional health authority, provincial health agency, Health Canada – all have roles for providing interpretation of the health issues contained within the guidelines. So there's a blend of roles here and you can't just say here's the health guideline without knowing something about the treatment technologies. Or how do you achieve the health guideline by implementing certain treatment technologies. So I'd say everyone has a bit of a role in relations. The guidelines don't exist by themselves. I mean, just look at the guidelines. They have all kinds of sections on treatment technologies, right? So, everyone I think has a role from the beginning, filtering the information down to a point where the local agency can communicate to the receiver of the water.
Through my experience I have. But not through the guideline itself. For the bacteriological definitely, they've got a lot of supplemental information that you can use in how to apply the guidelines and which circumstances increase or lower the risk. For example they make a point of mentioning you have to consider other water quality indicators and you have to consider has there been a break and you have to consider the size of the distribution system and the source, *etc*. They really present it in more of a risk assessment model you can use in determining whether or not you have to issue an advisory and what the significance of what that sample result is. But for some of the chemicals it's not clear at all. They say here's what we think, we hashed out this guideline based on the information that's currently available. And so, we set out a guideline value here but the scientists and researchers will say it's inconclusive. It's precautionary, right? You have to use that guideline and so it's all in the communication to the public. It just makes it really tricky.
The first step is to trust your expertise but some additional guidance would be good.
Currently, I don't apply them at the working level so I can't comment. More education would be nice.
Some guidance.
Yes.
There is room for improvement. There needs to be better communication between health and other departments (*i.e.* environment). Like I always have a challenge because say for example there is a proposed new guideline. So it comes over to Health for comment on it. And I'll have a look at it and then I'll consult with the chief medical health officer and, and we'll also send out to the regional health authorities to, to the regional health officials out there. And try to get their attention. And uh…in other cases, we don't get any type of comments back unless there's a vested interest in the protected or guidelines in terms of the experience with it or, or they're currently dealing with an issue. So to just send them additional documents, I don't think that that's going to do it. Maybe Health Canada could come to each province. But there is knowledge that is available to us and if we don't get answers at the provincial level we can go to Health Canada.
No, there is not much there. There is a little bit within each specific chemical parameter. I think it would be useful.
No, I don't recall ever getting any real guidance - just aware of the document - would be useful but don't use a lot. I have no formal training in risk assessment. I have not been to any formal sessions that discuss the guidelines. It would be useful but we don't use them a lot in the work that we do because we don't have the requirement in our

Table E29. Summary of Responses for Questions D3

Do you feel you have received adequate Guidance on the application of water quality guideline values? Who has/should provide this guidance? In What form should this guidance be provided?
regulations. Not sure if that is justified - probably isn't necessary to test for everything.
We really have gotten no guidance from anyone other than internally. We can interpret the guidelines adequately enough. I would hate to see them spend significant resources on a promotional tour amongst professionals who already know what the guidelines are - the general public should be the target. Not required, fine for provinces to develop own guidance.
In the documents but apart from being proactive, don't see any proactive activity from Health Canada. Guidance should come from Health Canada but it is our job to adopt it as policy.
Yes, it could be done in the certification schools, it could also happen by health authorities. Health authorities have a responsibility to ensure their staff receive adequate training. The issue is around the continual reinforcement of training - one snap shot training would not be valuable it would have to be continuous and that is a big piece.
Could always use more.
No. Health is failing. Need better training and education (*i.e.*, like Playsafe); Professional organizations could contribute.
Health inspectors, public health professionals have not received adequate guidance. Nobody has in depth knowledge because they are not involved - they have their own problems and agenda. Nobody has in depth knowledge of how the guidelines are developed or set. But I think most of them know about the technical document. When there is a new guideline document I inform everyone in Alberta. Public health inspectors are involved in a large number of things - water is maybe only 5% for them. The application of guidelines is questionable - we need to do better. HOW? Well, the information is there on the web site so if someone wants to know, they can educate themselves
I couldn't tell unless something happens. On the turbidity issues, I believe we have enough to go on. If I don't know, I know where I can go. I am comfortable that I will find someone quickly that would tell me if a slight exceedance is something to worry about and what the safety margin is. I feel comfortable that there is a big enough safety margin put in that 1 over is not going to matter too much – it is a warning sign.
No, it is up to the individual to do their own research. There should be more guidance on the guidelines because people are relying on the numerical values but should be in the risk assessment mode.
No. As a regulator we take them at face value and assume that the MHO or drinking water officer has vetted the guideline. So when you are interacting with your water supplier you assume that there is good science behind it. Personally I don't spend a lot of time working with the guidelines. Compare water quality reports to the guideline numbers. However, there is benefit to having a greater understanding of how the numbers are derived.
It might help to advertise the safety factors that are built in. But for chemicals, if there was something that explains what the science tells us and what the safety factor is, that would help.
Could get more guidance form Health Canada.
So with developing that information and getting it out there and available to people to

Table E29. Summary of Responses for Questions D3

Do you feel you have received adequate Guidance on the application of water quality guideline values? Who has/should provide this guidance? In What form should this guidance be provided?
use, they have to consider who is going to be using it and what additional resources might be needed to make it easier for people to use that information. Health Canada has a great depth of knowledge and expertise at their finger tips but they tend to forget that the average health inspector in the field may need some help with the interpretation of these changes. With Health Canada, the resources are there, it is great, we need that federal approach and we have to have that broad look at what is required across the country – we have enough of that even with the guidelines.
Have not received any guidance on applying drinking water quality guidelines. The province should appoint a specialist to assist smaller health regions. Smaller health regions could use more education for their health professionals.
When you look at health inspectors, we are generalists,, we deal with so many things, food, housing, animal control. We can't be all things. But we need more base information and the ability to know where to go if we have more questions. Health Canada needs to provide us with more interpretation. There tends to be an academic approach that does not translate well in the field.
Yes and no. We get a certain amount of training. I think anyone could look at the numerical value and compare that to water analysis results. The difficulty comes in when applying the guidelines and justifying your decisions with evidence. So often what we get – looking at turbidity, we can use that to argue for filtration and the supplier can use the same document to argue against the need for filtration. Overall we do get a fair amount of training in understanding the issues. Where we have problems is in convincing everyone else that we are right.
No, actually, it has been trial by fire. Jump in, take what you can get and apply it to a situation when it comes up – learn from the experience by some critical thinking after the fact and hope you do it better next time. I can't think of any training that we have had that is specific to getting the hands-on public health staff to the point where they can use this data appropriately and make an appropriate interpretation. Yes, there should be some formal training provided. I would suggest that the public health agency of Canada should advocate to the post secondary institutions that they review their curriculum and in all of their public health training programs they should be including a higher level of risk assessment, communication, and management training and some of that directed specifically at the guidelines. It should start right when we get the candidate into post secondary education that way they get formal training and they can apply that in a practical setting out in the field. We would get a much better level of public health professionals. I already mentioned training sessions, workshops, video conferencing all of that would be reasonable approaches. I like the idea of a course that could be offered on line or by distance learning so it would not be limited to those in large centers especially because a lot of the water issues are with smaller systems in smaller communities in the country.
I have sought out additional advice so I feel as though I had adequate guidance on it. Could always use more and a a more continuous effort is required to keep colleagues and new staff up to speed to understand the limits of interpretation what the GV mean and what they don't mean. There is a risk for people to act in a self serving manner – I don't have a problem with HC having a national guideline. It is the right place for it and prevent us from having provincial standards – the provinces can run away with things to. The training should come from academic institutions. Nice to have

Table E29. Summary of Responses for Questions D3

Do you feel you have received adequate Guidance on the application of water quality guideline values? Who has/should provide this guidance? In What form should this guidance be provi[illegible]d?
guideline development at an arms length. Province should coordinate training with RHAs.
I would say yes, mainly because I have gone out and looked for that information and get directly involved with a lot of the water supply systems especially with my role here in applying the guideline numbers and guiding other staff in trying to make a decision around them. But new public health professionals are not receiving adequate guidance. I think there is a real lack of training opportunities for them and having adequate people to teach them how to use the guidelines with experience in things like that. Tough question. A lot of different responsibilities at different levels. First off, there should be some responsibility on the individual who is expected to take on this role. I do think that people involved in setting drinking water standards should have a health background so that they can understand the health impact or consequences from drinking water. So I think that some individual responsibility in getting the appropriate learning and education is a priority and I think the education institutions have to be providing the appropriate courses and then employers have a very strong responsibility that when they are hiring people that they hire the people with the appropriate training and educational knowledge and they provide them with the additional knowledge and experience and continued training to keep abreast within the field. It is enormous, I have a hard time keeping up with the various journals and reading and research and keeping our staff up to date in the directions we are taking in drinking water. Governments, especially HC should provide more time and money in providing training and opportunities and funding this kind of work.
There are a couple of things: 1.Working with the provinces is very important; 2: Collaboration with Health Canada through the Canadian Public Health Inspectors Organization through conferences and seminars, etc. The offering of courses by Health Canada either on line or in major cities throughout the country to explain the guidelines – it would not be a one-off thing. Maybe a course on how to apply the guidelines, how they are derived, how they should be interpreted. I would like to see some more communication from Health Canada to the people in the field who are actually doing the work and that could be in a number of ways.

Table E30. Summary of Responses for Question D4

What can Health Canada do or provide to ensure the consistent and reasonable application of the guideline values?
When we're put in a position of trying to apply their guidelines, the population or the media are getting smarter and asking lots of questions that we don't always have quick access to how these guidelines were decided upon. It is important to know the process and how they come to their guidelines, it's clearly complicated and there's clearly lots of study and there's clearly a review and there's clearly allowances made sometimes for a lot of different perspectives. The provinces and the local agencies have to work out the local protocols. So you know, right now, X months after the BDCM guideline came out, we're now looking at a chemical exceedance protocol because we've never had one before. And they never even had a reporting relationship on chemical exceedances. It was never really established so it was ad hoc. It's like are they just locked away in Ottawa developing guidelines or is it their mandate to actually meet with people, get the information out, talk to them, initiate dialogue. I would never ever complain if someone wanted to provide us training or discussion on issues or provide guidance. But you know, I mean, three years ago, I can give you loads of examples of local agencies having no budget to pay for education. So what's the point of publishing a guideline? Heck, I can give you some examples of local agencies not even having internet access. So I mean, if you're publishing a guideline and throwing it on the internet saying go to it but that agency can't even get on the net or can't even pay for the paper to publish the guideline, you know, it's kind of a buck passing thing that they're doing. So yeah, I think there's lots of opportunities for education of the agencies, the public, the providers and working on getting people together. And practicing how to respond to issues like chemical exceedances.
Improve the messaging around how to use them. May be useful to have more than just one guideline value. Set the primary objective as precautionary and the second as a do not exceed threshold. A primary and secondary action level. If the uncertainty factor is high, maybe set those in a different class of guideline.
More on how to communicate with public regarding what to do when there is an exceedance.
It would help to label select parameters as priority contaminants and priorities versus optional or tiered. You know, these are the minimums in terms of these ones you have to meet. We know these ones have significant health impacts and if you can, well you can meet the other ones too, that's great. I mean, that's what happens in the real world simply because of cost.
More communication down. Provide how-to guides for some things.
There are issues with lack on consistency but I am not sure how you would change that or if it should be changed.
It is really nice to have the numbers but a more practical interpretation of what the numbers mean would be useful. For me what would be nice is if they could provide response action and appropriate treatment. I know they don't want to recommend specific devices but general things or practical tools we can use. Just be notified when there are updates - be added to a mailing list.
It would be nice to have some tools to use that would give us an indication of what parameters we do need to test for. Rather than just asking for Bac-T, it would be nice to have something else to determine in a knowledgeable way to say you should also test for this, this and this based on this, this and this. Guidance on determining relevancy. Free testing - for small systems it can be a limitation.

Table E30. Summary of Responses for Question D4

What can Health Canada do or provide to ensure the consistent and reasonable application of the guideline values?
There is a misconception about microbiology because people drink water out of lakes *etc.* and expect no ill health consequences. The other big misconception is that we, health authorities are responsible for the monitoring water. Many people, even on private systems assume the government is checking their water - this is not the case. No one has ever given this message to the general public.
Look at other programs. Federal documents are downloaded to give you the resources to take care of business but you have to develop your own policies and procedures in your own geographical and social and economic climate.
Not sure, different priorities in different provinces. You can take a different approach they just have to be based in the same scientific principles.
Need to stop abusing the precautionary principle. There is a lack of understanding of it at all levels and it is used wrongly. No known active outcome. Health Canada should explain how to apply/use the MAC. It would be good to see more health input on the CDW - currently mostly engineers.
We are realistic on the operational level. We understand where we are going but nobody is going to spend a lot of time daydreaming about the next new parameter we should be moving towards - not enough resource or capacity. We are more focused on reacting than inventing a new process. So it is nice to have Health Canada looking into issues for us. Health Canada has a real venue to go outside the country for information. We live by their guidelines because it is the best we have. If they develop a guideline we will follow it best we can, while making it work for us. But it can be very difficult to move away from a guideline because there is an expectation that they will be followed. That is the system that exists. We run 7 programs so there are 7 competing interests on the table.
I think the program serves a useful function. But it is only one thing of the many things that helps in assuring safe drinking water.
Implement checks and balances into the system - if something is happening get it to somebody else
In each province there is a lack on consistency and resources are being wasted - we need tools from Health Canada to help us determine how it all fits together. They need to work on building integrity and earning public trust.
They need to be a resource. It would be nice if they could provide us with a more practical way to apply the guidelines - a range? Could include scenarios and examples that explore different situations - at least to have the conversation at the federal level because health authorities are likely dealing with the same issues and right now are not sharing information.
I would be open to hearing about a better way. Particularly for situations when you are close to the guideline. Standardization would be nice. Could be more proactive. Smaller health agencies are forced to be reactive.
One frustration I have with the guidelines in general from a regulatory point of view is in not having a strong enough recommendation. All that we have, say with the filtration example, is that the language in the guidelines is should filter, is recommended. Okay but if it is a better idea and the best practices, how can I use this to affect change and it does not give me enough to go and order somebody. I don't know if there is anything more the GCDWQ can do. If there is going to be national enforceable standards there also has to be a program to fund that so that the systems

Table E30. Summary of Responses for Question D4

What can Health Canada do or provide to ensure the consistent and reasonable application of the guideline values?
have a chance of making the required upgrades. We can't just look at a number and say you have to meet that number. At the other end of that, there has to be a darn good reason for not meeting it. So there has to be consistency in the risk assessment process. The numbers are important for giving us a place to start and some of the numbers will be harder to apply than others. For example, there is not much comfort in going above the arsenic MAC. Whereas something that doesn't have that much information or present the same health risk as arsenic or an aesthetic objective – there may be inconsistency there. There may be economic considerations.
At some point in time, because they are a guideline, how do you apply them? They are not a regulation or a standard, they are a guideline. By re-vamping them is it possible to pull out the critical issues and have them at a higher level of regulatory accountability. I think that would certainly help those of us who are at the front line dealing with these specific issues with being able to fall back and say this is what senior government has said is important and this is the standard that on behalf of the Canadian communities that they have said will be our standard of practice and get on with it and be accountable. It actually goes beyond the 4-3-2-1-0 approach and putting that at a higher level of accountability. That is just one barrier in the multi-barrier approach. All of these other accompanying documents should be in place to support the evidence of the multi-barrier approach. That's where the accountability should lie. Here is the reason and here is the stuff that tells you what standards to get to meet a multi-barrier approach.
HC tends to run away with numbers a bit. Quite a strong lobby from some of the provincial environmental groups. Need to be critical about how many numbers we are putting into the guidelines and what parameters are significant enough to bring in as guidelines. Even though they are called guidelines they have the effect of being treated as regulations. I would rather not …where t do you stop? There is an endless number of chemicals you can monitor for. What resources are we going to spend on this and what are the health outcomes. What are the costs including missed opportunity costs. We need to really focus on what the parameters of greatest concern are.
I think the main part is that they provide an incredibly good reference point for starting to evaluate drinking water quality and I think it is essential. We need the guidelines and they are required. I do have my preference that they remain as guidelines and I think that as they remain as guidelines it is easier to make amendments to them as new information is available in regards to them and I think it allows you to apply them and use an awful lot more risk-based decision making in regards to evaluating the water quality and the risks that users can be exposed. I certainly don't want to see each province developing their own guidelines. I think having Canadian guidelines works very effectively.
Provide guidance on frequency of sampling and what to sample for.
Need formalized public health surveillance system to identify enteric illness.

Table E31. Summary of Responses for Question D5

Any additional comments?
Simply put - 80 percent of the population is serviced by high end systems. Twenty percent lower end systems like making it really simple. But realistically, where's the higher risk on a regular basis? They've got like a once every ten years, big system outbreak versus a fairly regularly occurring problem in the smaller systems so…and I don't really like the guidelines – the way they've divided public, semi-public and stuff like them and applying different levels of risk. They're not really clear on that. It's kind of loose. It, you can see there's an influence of people who are maybe more representative in municipal systems *vs.* small systems. They have to fix the communication schism that exists between the ivory tower that is Ottawa and remote agencies down to the local person in the field. They have to bring that together. They have to fix the communication aspect first and bring the right people to the table and then develop the documentation so that it can be targeted to the intended recipient. I think they actually act sometimes like it's just up them to produce a guideline. It's up to the province or the municipal agency or whoever to decide what to do with that guideline. So they ride a fence. They work to create this guideline but there's no money for distribution or support for helping people meet the guideline. It's kind of esoteric. It just sits there in the background.
Mechanism is required to monitor trends and not just wait until there is an exceedance. There should be a trigger response if there is a significant change in water quality in that plant should trigger some response. But in the end of the year, I mean, water quality is translated into numbers. If they're below the numbers, they're okay.
When they set a value, are they setting it for a health based outcome? If they are, why is environment at the table? That is not their job.
I think Health Canada should develop a guideline and provide you with the background information. And then from there, as the regulator, it's our responsibility to kind of come up with the how.
I guess it would help if there was some sort of, further explanation in the guidelines or in the document that detail when these guidelines or when these parameters should be tested for; So we would look at many other things. The semi-public systems that health regulates that we, we primarily be focusing on the attention on the microbial concerns. We are going to get to the point where we have to look at chemicals. Then it's going to be challenging because many of these water supplies are seasonal in nature and it's short term exposure. So what do you do? So you have an elevated level of a chemical in a public water supply at a campground. So are we going to immediately require some sort of advisory or, or require treatment to be incorporated into the system for a short term exposure when the information is based on chronic exposure or long term exposure?
Don't have a flow chart to work through if we have an exceedance - something we should have but it would be very difficult because there are many types of systems. A lot of people are web savvy now and therefore they would go to the website and look themselves so showing a hierarchy would help.
Guidance on determining relevance for application; more stringent does not mean lower numbers it means giving us more authority to enforce the guidelines. National standards are a great idea as long as the money comes along with them.
Occasionally we have problems with people wanting their water sampled for chemicals but not understanding that you need to have an idea of what you are looking for before you start sampling.

Table E31. Summary of Responses for Question D5

Any additional comments?
Is it in Health Canada's mandate to promote the guidelines? I think so.
Because the supporting technical documents are fairly well read by health inspectors, I think there could be some additional information in there on what principles the particular value is set on. They are very well read. We generally prioritize what chemicals to sample for by doing a risk assessment on source water (*i.e.*, type - surface or ground, historical issues, openness to contamination, *etc.*). More guidance on sampling methodology and laboratory accreditation. Reporting dissolved or total concentrations and bioavailability that we should be looking at dissolved *vs.* total. We have always gone on the total side.
Evidence of some dysfunction on the CDW - political agenda?
National standards would be fine but you have to be prepared on the economics side of it. For the little communities, who pays? Guidelines provide you with what is commonly accepted. Precaution is good but this is a small world and resources are always going to be competed for and investing resources in something that is unknown, with an unknown result, still knowing that you may have an unintended result that is worse than your unknown you are trying for - I would tell you, hold up the bus. If you can get a positive effect, with a measurable result - much better. If there is no product, how do you sell it.
Can cost 30 million dollars to address elevated THM levels - is it worth the expense? Tough question to ask. Can't answer if we are doing the right thing. How do you measure improvement to public health if you don't know where you are starting - don't know how much cancer in the population can be attributed to THM.
But you do have a percentage of people that are black and white and if they are in that field – they will apply it that way. But grey still wins as long as the process is such that common sense comes to the forefront. If we reacted to every slight exceedance – we would have chaos – chicken little.
Numerical values help make operators feel better because they meet a guideline. Nothing is black and white, maybe when there is insufficient evidence we should recommend a range.
National standards have merit and it would make things more straightforward. Sampling frequencies are very inconsistent - that is something where national standards would be useful. But politics is an issue. A decision tree approach with basic framework for all.
We need to look at things logically and there needs to be discussion - we lose sight of the practical sense when looking at risks from drinking water relative to ther public health issues. Need to work together with other groups to be consistent. If everyone approaches issues the same way, the public will become more comfortable with our approaches. There may be a place for national standards for certain parameters that we have a lot of evidence for but it is nice to have discretion for different systems.
Larger health regions are getting better with sharing but the provincial health or environment agency should take the lead and provide information to health regions. Our provincial health agency has not been proactive. If there was an issue I was dealing with, I would not consult with Health Canada.
Having these guidelines as non-enforceable standards does create a problem in one respect. We will put it out there and say these are our requirements but if anyone actually challenges us on them, our lives are a lot more difficult. As issues come up we will be looking to the guidelines for help. You look at endocrine disrupters and

Table E31. Summary of Responses for Question D5

Any additional comments?
PCPs, *etc*. the science is not clearly understood, yet a group was successful in getting a bylaw passed to prevent sewage discharge into a lake because treatment does not deal with these things. There is not enough information on these parameters and there are no regulatory standards for these things but there was enough fear to get the government to pass a by law.
What we have is a varied group right now. Particularly within the PHI area. A lot of the young people have a much higher level of understanding of risk assessment and risk communication than say people that were trained 30 years ago. So there are still a lot of guys like me that stayed in the field level and did not get any further education around it and their understanding is straight black and white. The young people have a much greater of understanding of risk assessment and what it means and have a better ability to actually apply it. I sense the change in educational requirements and the professional development/upgrading – the newer people have a much better understanding.
I think it is important to keep in mind that these are guidelines and as such we use them as a reference stick to compare what our water quality is for whatever water supply system it is to those guidelines and if there is any noticeable difference between what the guidelines have and what we are evaluating and seeing in our drinking water system than we will address it at that stage. So I think that the guidelines are good to use as a reference guide and we will use that information to evaluate the quality of the drinking water in our drinking water systems.Fortunately I know that a couple of the guidelines that have been developed, were developed in response to some higher level pressures within the Health Canada system rather than in direct response to actual health risk and that concerns me. Things tend to get a great deal of response in the public that is out of proportion with actual health risks and a more thoughtful approach based entirely on the evidence that can be verified …rather than responding entirely to perception of reality. I struggle with the idea that it is government's business to oversee public health process. I think the model of an independent agency as a single head that is accountable only to parliament is a better model because it would be less susceptible to political influence and outside influence of all kinds –out of a government ministry and an independent agency only accountable to parliament.